

JPRS-CEN-90-003
19 MARCH 1990



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Science & Technology

CHINA: Energy

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SPRINGFIELD, VA. 22161

19980122 141 DTIC QUALITY INSPECTED 3

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Science & Technology

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Strengthening the Energy Industry During Rectification Period

906B0026A Beijing RENMIN RIBAO in Chinese
24 Dec 89 p 5

[Article by Huang Yicheng [7806 3015 6134]: "Conscientiously Reinforce the Energy Resource Industry During Administrative Rectification"]

[Text] There must be a rational ratio between the rate of growth in the national economy, particularly in industry and agriculture, and the rate of growth in primary energy resources.

We should take full advantage of China's relatively abundant coal resources, increase inputs, and accelerate coal development. Arrangements for thermal power construction should focus closely on conserving coal and transport, and we should accelerate hydropower development. The petroleum and natural gas industries should concentrate on "increasing reserves and raising output," and increasing reserves is an urgent task. Developing nuclear power is an important step for future solution of east China's energy resource problems.

Carry out good administrative rectification and expend over 90 percent of our efforts to exploit potential within the energy resource industry.

The 5th Plenum of the 13th CPC Central Committee decided that, including 1989, it would take 3 years or longer to finish administrative rectification tasks in the national economy. The energy resource industry is an important basic industry and the question of conscientiously achieving reinforcement and stable development via administrative rectification and intensified reform is very important in promoting a movement in the national economy toward sustained, stable, and coordinated development. I will discuss some views on this question and study them with everyone.

I. The Rate of Development of Energy Resources Should Correspond to the Rate of Development of the National Economy

There has been a comprehensive energy resource shortage in China since the last half of 1988. Was it due to declining energy resource output? No. Actually, the energy production situation was quite good in 1988 and 1989. This was particularly true for coal and electric power production where there was very rapid growth instead of slippage. Raw coal output in China reached 980 million tons in 1988, up by 5.6 percent over 1987 (the growth rates for 1986 and 1987 were about 3 percent). Electric power output in China reached 545 billion kWh, up by 9.6 percent over 1987 and sustaining the rapid average annual growth rate of about 10 percent in the first 2 years of the Seventh 5-Year Plan. Energy resource production continued to expand in 1989. China produced 920 million tons of raw coal up to the end of November, an increase of more than 70 million tons over the same period in 1988 and a 10.1 percent growth

rate. In a situation of basic equilibrium in electric power output during the first quarter of 1989 compared to the same period in 1988, there were increases in subsequent quarters. A total of 525.7 billion kWh of power was generated up to the end of November, an increase of 6.9 percent over the same period in 1988. Projections are that raw coal output definitely will exceed 1 billion tons in 1989 and power output was exceed 570 billion kWh, surpassing state plans in both areas and achieving plan indicators in the Seventh 5-Year Plan 1 year ahead of schedule. State plans were also completed in petroleum and natural gas production.

There are several reasons for the good achievements in energy resource production in 1988 and 1989. First, there was concern and support by leading comrades in the CPC Central Committee and State Council for the energy resource industry and coordination by relevant departments and local governments. Second, a sense of responsibility and being the masters was fostered among the ranks of workers by comrades and employees on the energy resource battlefield who showed concern for the state's problems and worked hard to increase production. This is particularly true of the period of disorder and counterrevolutionary rebellion in Beijing and certain other regions when most employees on the energy resource battlefield held firm at their posts, scrupulously and respectfully stayed at their jobs, and displayed a high degree of political consciousness to assure normal operation in energy resource production. Third, system reforms and expanded decisionmaking rights for enterprises motivated initiative in all areas and promoted production.

If the energy resource production situation has been so good over the last 2 years, why does the energy shortage persist? The basic reason is a loss of macro control and proportion. Many years of experience in China and foreign countries have proven that there must be a rational ratio (usually expressed using an "elasticity coefficient") between the rate of growth in the national economy, particularly industry and agriculture, and the rate of growth in primary energy resources. This is the fundamental condition for achieving an overall balance in energy resource supply and demand. Many experts feel that the elasticity coefficient for energy resources during times of high economic growth rates should be over 0.5, while the minimum elasticity coefficient for electric power should be greater than 1. In the first 3 years of the Seventh 5-Year Plan, the elasticity coefficients were 0.26 for primary energy resources and 0.67 for electric power, far below requirements, so an energy resource shortage was inevitable. Thus, a basic solution to the contradiction between energy resource supply and demand must be a firm decision to readjust the serious loss of proportion between the energy resource industry and other industries during this administrative rectification. Plans call for primary energy resource output of 1.4 billion tons of standard coal in the year 2000 and a yearly growth rate of only about 3.5 percent over the next 10 years. The growth rate for the gross value of industrial

and agricultural output can only be set at 7 percent, so the rate of growth in electric power must exceed 7 percent. There should be simultaneous proportional increases or decreases in growth rates for energy resources and the national economy in future national economic plans. If the corresponding growth rate is not reached in the first year, a small readjustment should be made in the second year. Otherwise, a small loss of coordination accumulated over several years will add up to a large loss of coordination and eventually compel major economic readjustments leading to excessive losses in all areas. Thus, I feel that we must discuss plans and arrange proportions, which may be somewhat more scientific than "slanted policies" usually discussed.

II. Start With China's National Conditions, Adopt Correct Energy Resource Development Strategies and Policies

China can truly be said to be rich in energy resources. First, we have coal, with proven reserves now of more than 860 billion tons. Second, we have hydropower, with developable hydropower resources of 380,000 MW. The regional distribution of China's energy resources is extremely uneven, however. Economically developed areas of east China have fewer energy resources, limited energy resources available per capita, seriously inadequate investments for development, and a very low energy resource utilization rate due to backward technology and management. These are the basic advantages and disadvantages of China's energy resources and are our basic national situation in the area of energy resources.

After establishing the Ministry of Energy Resources, we started with China's national conditions and formulated a two-stage goal requirement for our economic development strategy to the end of this century. We studied and proposed basic principles and development strategies, policies, and measures for the energy resource industry in the medium and short term. The basic ideas are:

1. Take full advantage of China's relatively abundant coal resources and increase inputs to accelerate coal development. Concerning deployments, one thing is a national focus on developing coal in the "three wests" region of Shanxi, Shaanxi, and west Inner Mongolia, particularly Shenu Dongsheng Coal Field which has reserves of more than 200 billion tons. The key is to focus on opening up major coal transport arteries to ship coal out of this region. Second, we should accelerate development of Dongsimeng lignite and east Heilongjiang and Liaoning coal and cease shipping coal out of Shanaiguan to free up Shanaiguan's coal and transport capacity and protect east and south China. Third, we should reinforce coal development in Shandong and Anhui, Yongcheng in Henan, and other parts of east China as well as Yunnan, Guizhou, and other areas to try and reduce coal shipments from north to south and west to east as much as possible. Fourth, we should give preference to developing large-scale open pit mines along with stronger technical transformation at

existing mines and much higher levels of mechanized excavation to compensate for declines at old mines and raise labor productivity and safety levels. Fifth, local coal mines now account for more than one-half of coal output, so we should truly strengthen management and focus on rectification and transformation to assure healthy development of this "half of the sky." We do not advocate individuals running mines.

2. Thermal power construction should focus closely on conserving coal and transport capacity. We should use high parameter and high efficiency large generators in all thermal power plants built in the future, develop super-critical generators, and gradually eliminate moderate and low pressure small generators and generators which have exceeded their service lives to try and save coal. We should actively develop pit mouth power plants, implement joint administration of coal and power, and shift from transporting coal to transmitting power. We also should accelerate hydropower development to reduce pressures on coal development and railroad transport. In deployments, the first thing is to focus on building large hydropower stations on the upper reaches of the Huang He, the trunk and tributaries of the Chang Jiang, the Hongshui He and Lancang Jiang, and so on, and second, to build several medium-sized hydropower stations in regions with energy shortages and good hydropower resource conditions.

3. The focus in the petroleum and natural gas industries should be placed on "increasing reserves and raising output." Increasing reserves is an especially urgent task. We should stabilize old oil fields in east China and strive to explore and develop petrolierous regions of west China. Continued cooperation in exploration and development of offshore petroleum should be combined with reinforcement of our own exploration.

4. Developing nuclear energy is an important way to solve China's energy problems in the future, especially along the east coast. In this century, the main focus is on grasping nuclear power equipment manufacturing technologies and basically achieving domestic production and batch production of 600 MW grade nuclear power equipment to lay a foundation for rapid development of nuclear energy in the 21st century.

One key factor in achieving the development strategy outlined above and development goals for the end of this century is to increase investments in the energy resource industry. Comrade [Deng] Xiaoping recently emphasized that we must reinforce investments in the energy resource and other basic industries and that we "must hold firm for 10 to 20 years, so I would rather that we go into debt and still be able to reinforce them." For this reason, the state should try to increase investments in the energy resource industry as much as possible in accordance with industry policies and readjust the direction of investments, and it should continue implementing policies for everyone raising money to develop energy resources, establish a coal construction fund, and perfect electric power and petroleum construction fund

methods. Coal, electric power, and petroleum enterprises should be encouraged to use more foreign investments. We must gradually straighten out energy resources prices, reverse the loss situation in energy resource enterprises, and strengthen the vitality of the energy resource industry.

III. Do Good Administrative Rectification, Use More Than 90 Percent of Our Efforts To Exploit Internal Potential

There is no doubt that in this administrative rectification, the energy resource industry is a basic industry which requires major efforts to reinforce and accelerate development, and it is essential that all areas try to increase investments. Coal mines, power stations, and oil fields cannot be built without money, but we must understand that China is rather poor and has limited financial resources, so it is unrealistic to think of relying on the state for substantial increases in investments. For this reason, our standpoint should be "looking inward, exploiting potential" and trying to manage and use existing funds, equipment, manpower, financial resources, and so on well, trying in every possible way to increase labor productivity and economic benefits, and exploiting potential within all energy resource sectors and enterprises. Leaders at all levels should expend over 90 percent of their efforts in this area to attract the initiative of all employees toward internal exploitation and increasing results and efficiency.

Like other industrial sectors, the energy resource industry has undergone 40 years of construction and development. It now has a substantial foundation and considerable potential in all areas. Science and technology are developing rapidly and people's objective understandings are becoming more profound, so there can be continued discoveries of potential. A serious investigation reveals varying degrees of waste in plan deployments, design and construction, technical equipment, production management, capital and manpower utilization, and so on. The waste in some areas is frightening. There are big differences in labor productivity, materials consumption, construction schedules, and other areas, not only compared with the advanced nations but also comparing advanced and backward enterprises in China. This waste and difference offer realistic potential. There are many examples in this area:

In the coal industry, full staff productivity in all of China's unified distribution coal mines in 1988 was 1.092 tons per worker. The highest figure was 4.72 tons in Shanxi's Jincheng Mine Bureau but under 1 ton in 30 percent of mine bureaus. Average output per fully mechanized mining team in all of China's unified distribution was 520,000 tons per year. The highest was 1.8 million tons and the lowest was only about 200,000 tons, so we have not kept up with high level regular extraction. For new mines and mine transformation and expansion projects which have gone into operation since the Sixth 5-Year Plan, there are still over 50 million tons which have not attained design capacity, and so on.

In the electric power industry, China's 1,000 MW grade thermal power plants usually employ 2,000 to 3,000 people, but Huaneng Dalian Power Plant (700 MW), now one of China's most advanced, uses just 500-plus people. Chinese-made 200 MW generators consume an average of 394 grams of standard coal [per kWh] to generate electricity, and the lowest is 364 grams. Millions of kWh in capacity of China's existing thermal power plants have not attained specified output due to equipment defects, poor management, and other factors, and so on.

There are many economically irrational areas in planning and design. For example, construction of a small condensed steam thermal power plant in regions covered by large grids has a high unit cost per kW and high coal consumption, and it pollutes the environment. Designs have not considered our national conditions and capabilities and have adopted too many high and too many foreign standards. There is no shortage of examples of this.

In the area of capital construction, long construction schedules and high construction costs are quite common. At a certain power plant in Beijing, for example, the estimated investment was 540 million yuan for an installed generating capacity of 600 MW, but the cost now may be double or even more. There are effects arising from increased materials costs, but there also is obvious waste. In contrast, some projects which did not receive a focus have been built too quickly and too cheaply because of a concern for careful accounting. At Lingwu Coal Mine in Ningxia, for example, two small shafts were built and later linked together to make one large shaft, enabling construction to be carried out at the same time as mining. Shenmu Daliuta Coal Mine has a scale of 3 million tons. It could be built in 3 years at an investment of less than 100 yuan per ton of coal and produce 1.2 million tons of coal in 1990. The construction schedule for 200 MW and 300 MW generators at thermal power plants usually takes 36 months from the start of construction up to the time they begin operating and generate power, and those built more quickly take only 24 months. Xin'an Jiang Hydropower Station, built during the early 1960's, has an installed generating capacity of 600 MW. The first generator began operating in 3 years but it now usually takes 6 to 8 years. For large coal mines of the 1 million ton grade, the fast ones take 40 months to complete and go into operation while the slow ones take 8, 9, or 10 years or even longer.

It is easy to see from these examples that we have substantial potential! To exploit this potential, after the Ministry of Energy Resources was established, we focused on work in this area. In 1988, for example, we proposed shortening construction schedules for energy resource projects as a breakthrough point to use existing capital well. We held an on-site meeting at Zouxian in Shandong and formulated several methods and measures. The main thing is emphasizing good preparatory work. Construction should not be started at projects without good preparations. Once construction begins, a

"full belly" of capital, materials, and equipment should be guaranteed and crack troops should be organized for continued construction. In 1989 we focused on improving the health of equipment in existing thermal power plants and undertook "creating levels and attaining goals in safe and civilized production" to achieve safe full output and stable power generation. The focus is on good administrative rectification in key enterprises. All grid bureaus and provincial [electric power] bureaus have focused on a total of 21 power plants and the Ministry of Energy Resources has focused directly on seven big power plants. Shift leaders are direct leaders on the first line in production and the quality of shift leaders plays a decisive role in safe production and labor productivity. We experimented with reinforcing first line guidance in Tiefang Mine Bureau's Xiaonan Mine. We are also focusing on a joint coal and power management project at Yimin and on key issues in planning and design, and so on. There is a big difference between focusing on these things and not focusing on them. In the area of reducing construction schedules, there are models for both coal mines and thermal power plants. Examples include the No 1 shaft at Santaizi in Tiefang Mine Bureau which can be completed and go into operation in 40 months, the 300 MW Chinese made generator at Zouxian in Shandong which can be completed and put into operation in 26 months, and the No 1 generator at Hanchuan Power Plant in Hubei which basically can be connected to the grid and generate power in 24 months. There have been obvious achievements in administrative rectification in existing thermal power plants. Jiangsu's Jianbi Power Plant, which has an installed generating capacity of 1,625 MW, is China's biggest thermal power plant. In the past, the average output was only 600 to 700 MW. Shanxi's Shentou Power Plant has an installed generating capacity of 1,300 MW but in the past six of its eight generators could not operate most of the time. After focused help, employees at the plants had an enthusiastic spirit and the people and equipment of the original shifts changed in a few months' time. Output at Jianbi Power Plant has now reached 1,200 MW and Shentou Power Plant is generating 1,000 MW.

Practice has proven that exploiting potential within the energy resource industry and increasing benefits and efficiency are extremely necessary and completely possible. The 5th Plenum of the 13th CPC Central Committee emphasized that our economic work must resolutely shift toward a focus on increasing economic benefits and major efforts to improve administration and management, raise S&T levels, show concern for economic results, establish strict accounting standards, and take the economic development route of fewer inputs, more outputs, and high results. If we earnestly adhere to the spirit of the 5th Plenum of the 13th CPC Central Committee and do good administrative rectification, intensify reforms, firmly organize and use existing manpower, financial resources, and materials well, fully motivate the masses, substantially increase labor productivity and economic benefits, and take

advantage of latent strengths, it will certainly be possible to strengthen the energy resource industry and gradually move onto the track of sustained stable development.

Development of Cogeneration To Achieve Energy Conservation and Environmental Protection

906B0016A Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 7, 5 Jul 89 pp 2-7

[Article by Liang Yongai [2733 3057 1947] of Beijing Institute of Water Conservancy and Electric Power Economics: "Development of Cogeneration as an Important Approach to Energy Conservation and Environmental Protection"]

[Text] I. Status of Cogeneration Development in China

Cogeneration of power and heat is an important way to conserve energy and protect the environment. Specifically, since the Sixth 5-Year Plan the State Planning Commission has issued a series of directives, notices and rules to forcefully push for the development of cogeneration. By the end of 1987, China had a total capacity of 6,680 MW of cogeneration units whose individual capacity is above 6,000 kW to supply 463.73 million GJ of heat. This is equivalent to consuming 18.19 million tons of standard coal. Compared to small furnaces scattered around, approximately 12 million tons of standard coal were saved, which is 7 percent of the 170.37 million tons of standard coal consumed to generate power and heat. From 1980 to 1988 alone, the State Planning Commission arranged to provide energy conservation funds to build 5,800 MW of cogeneration facilities. By the end of 1987, 1,600 MW was already in operation, generating 8 billion kWh of power annually. This saved us 3.31 million tons of standard coal and reduced the discharge of 1.8 million tons of particulates and 120,000 tons of sulfur dioxide which contributed to economic growth, energy conservation, environmental improvement and ecological balance.

However, cogeneration development is not moving fast enough in China. From 1980 to 1987, 2,130 MW of new cogeneration facilities were added (1,716 MW were units above 6,000 kW individually). The annual growth rate is 5.4 percent. During the same period, industrial gross product (relative) was growing at an annual rate of 12.8 percent. Thermal power generation capacity was increasing at an annual rate of 7.6 percent. The relative weight of cogeneration to thermal power generation capacity dropped from 11 percent in 1980 to 10 percent in 1987. In order to meet the demands for power and heat from industry, especially local industry, we had to build a large number of energy inefficient furnaces and small thermal power plants. China has over 40,000 small furnaces, consuming approximately 300 million tons of standard coal per year. We have 12,000 MW of condensing steam type small thermal power plants, consuming 31 million tons of standard coal per year. These are major reasons contributing to high energy consumption per unit of power generated, serious environmental

pollution and high coal consumption for thermal power generation in China. (The coal consumption rate was 397 g/kWh for power generation and 432 g/kWh for supplying power in China in 1987. Advanced level in foreign countries is 327 g/kWh.) Compared to the USSR, the relative weight of thermal power generation is 30 percent less. However, the coal consumption for power supply is 105 g/kWh higher.

The development of cogeneration power plants is also unbalanced. It began and made a great deal of progress during the period of 1953 to 1965. Some 2,400 MW of facilities with individual capacity above 6,000 kW were constructed, corresponding to 27 percent of the thermal power generation capacity added in the same period. This is the foundation of the cogeneration business in China. Between 1965 and 1980 the growth of cogeneration was slow to stagnant. Only 1,990 MW of facilities were put in operation in that 15-year period, corresponding to only 6.4 percent of the total thermal power capacity newly added in that period. Between 1981 and 1987, 2,250 MW of cogeneration facilities at above 6,000 kW level were put in operation. The annual rate of growth is only 6 percent. Nevertheless, thermal power generation was growing at an annual rate of 7.6 percent and industrial growth rate was 12.8 percent per year, corresponding to only 7.6 percent of the thermal power generation capacity newly added during the same period. In order to meet industrial demand for power and heat, we had no choice but to build many small furnaces and some small condensing steam type power plants. The relative weight of cogeneration capacity to total thermal power generation capacity dropped from 11 percent in 1980 to 10 percent in 1987. This is the main reason why we consume more coal to supply thermally generated power.

From a regional perspective, Table 1 shows a few provinces and cities where cogeneration was developing at a fast pace as of the end of 1987.

Table 1. Provinces and Cities With Rapid Growth in Cogeneration (as of end of 1987)

Name	Number of cogeneration plants	Capacity (MW)	Ratio to thermal power capacity (%)	Annual growth rate (%)
Jiangsu	97	466	8.5	21
Guangdong	48	299	9.7	12.1
Heilongjiang	43	804	18.2	13.5
Liaoning	29	1060	18.4	6.8

Most of our cogeneration plants are small and owned by individual users. There are some large ones serving regional customers. In the future, it is expected more medium size and regional cogeneration plants will be constructed. For example, among the 97 cogeneration plants in Jiangsu, 94 are small ones with a total capacity of 266 MW. There are three large plants with a total capacity of 200 MW. Eighty-three plants with a total capacity of 311 MW are owned of end users and 14 plants with a total capacity of 166 MW are for regional use. The technical economic targets for businesses have drastically been improved after these cogeneration plants were constructed. In 1987 there were 71 small nitrogen fertilizer plants in Jiangsu and 27 had their own cogeneration plants. The remaining 44 built small furnaces to supply heat. Their technical economic indicators are significantly different (see Table 2).

Table 2. Technical Economic Comparison of User-Owned Cogeneration Plant to Small Furnace in Jiangsu

Item	Ammonia production (t)	Coal as raw material (kg/t)	Coal used as fuel (kg/t)	Electricity consumed (kWh/t)	Total energy used (MJ/t)
All 71 plants in Jiangsu	1,299,914	1,088	290	1,166	55,936
27 plants with their own cogeneration plants	617,861	1,052	243	1,038	52,502
44 plants with furnaces	82,053	1,120	333	1,187	59,047
Unit energy savings		68	90	149	6,545
Total energy savings		42,000 tons of standard-coal	56,000 tons of standard-coal	920,700,000 kWh	138,000 tons of standard-coal

The 71 small fertilizer plants in Jiangsu can produce approximately 1.3 million tons of ammonia per year. The power load is 180-240 MW and they consume 1.45-1.6 billion kWh of electricity. Because 27 plants (with a total of 618,000 tons of ammonia production capacity which is 47.5 percent of the capacity in the province) built their own cogeneration plants with a total capacity of cogeneration of approximately 90 MW, 500 million kWh of electricity is generated yearly. This not only provides one-third of the power requirement of all the fertilizer plants in the province, but also saves 56,000

tons of standard coal as fuel; 42,000 tons of standard coal as raw material, and 920.700,000 kWh of electricity. As a whole, this corresponds to an energy saving of 138,000 tons of standard coal.

Not only small fertilizer factories have their own cogeneration power plants, but also small chemical factories, sugar mills, breweries, oil refineries, paper and pulp mills, textile printing and dyeing plants, knitting mills, agricultural chemical plants, woolen mills and chemical fabric plants also either have their own cogeneration plants or built

small cogeneration plants in conjunction with other small businesses so that heat can be supplied in a concentrated manner. Thus, not only heat needed for production is

solved but also a part of the heat needed for everyday use. It is beneficial in terms of energy conservation as well as environmental protection, as shown in Table 3.

Table 3. Technical Economic Indicators for Several Small Cogeneration Power Plants in Jiangsu (1985)

Item	Unit	Xinyi Cogeneration Plant	Nantong Printing and Dyeing Cogeneration Plant	Suzhou Cogeneration Plant	Wuxi Shuanghejian Cogeneration Plant (Aug-Dec 1985 data)
Number of furnaces x model		1 x WGC35/54-1	2 x WG35/39/450	2 x WG35/39	2 x VG35/54
Number of turbines x model		1 x B3-49/5	2 x B3-35/5	2 x B3-35/5	2 x B3-49/8
Steam capacity	t/h	29.6	54	54	60
Power plant investment	10,000 yuan	660	1,097.7	1,347	1,510
Heat network investment	10,000 yuan	50	40	100	130
Annual heat supply	GJ	321,965	859,173	601,434	184,219
Annual power generation	10,000 kWh	903.6	3,322.3	1,827.0	617.3
Coal consumption rate for power generation	g/kWh	287.7	182	233	256
Coal consumption rate for heating	kg/GJ	53.9	48.5	48.0	56.4
Power used by power plant	%	24	1.9	17.8	6.6
Power used by heat generating plant	kWh/GT		5.0		5.14
Coal consumption rate for power used	g/kWh	378.6	214	283.4	274
Standard coal cost	yuan/ton	124.2	138.6	134.3	140
Cost of power generated	yuan/kWh		50	74.7	140
Cost of heat supplied	yuan/GJ		8.1	7.76	8.96
Hours of utilization of heat supplied per year	h	3,707	5,682	3,800	
Hours of utilization of power generated per year	h	3,012	5,537	3,045	
Hours of operation of the system per year	h	7,600	6,760		
Mean heat load	%	48.8	84.1		
Coal saved per unit heat supplied	kg standard coal/GJ	-1.36	4.06	4.54	-3.82
Coal saved per unit power generated	kg standard coal/kWh	7.9	34	23	23.7

II. Major Existing Problems

Over the past 30 years, especially since 1980, our experience shows that cogeneration is obviously economically beneficial. Due to economic growth, cogeneration is also in very high demand. How come cogeneration grows so slowly while industrial growth is so rapid? Why has the relative weight of cogeneration in thermal power generation decreased? The major problems are as follows:

1. There is a lack of understanding of the significance of cogeneration. By the year 2000, we have to quadruple our electric power production. However, we can only double our energy production. The balance must depend on energy conservation. Cogeneration is a significant way to conserve energy. The combined overall thermal efficiency of cogeneration of heat and electricity is 65-75 percent. Compared to separate production of power and heat which has an overall thermal efficiency of approximately 42

percent (50-55 percent thermal efficiency of a small furnace and 30 percent efficiency of a condensing steam generator), the net result is an improvement of 66 percent. There is a lack of understanding of this point. For example, in 1987, 10 percent of the total thermal power generating capacity above the 6,000 kW level could cogenerate heat and power. The amount of energy consumed to generate electric power was 170,370,000 tons of standard coal. Out of that, 18,190,000 tons were consumed to produce heat, which is 10.7 percent of the total. Compared to separate production of heat and power, 12,000,000 tons of standard coal could be saved. This amount of coal saved can be used to generate 6,000 MW of power. If the relative weight of cogeneration is raised from 10 to 30 percent, then 3,500,000 tons of standard coal can be saved annually, which represents 20 percent of the energy consumed to generate power and can be used to generate 18,000 MW of power. From Table 3, although a cogeneration system is small, yet its coal consumption rate for power generation is only 214-379 g/kWh, which is comparable or lower than that of a 200-300 MW condensing steam generator.

Some comrades do not understand the environmental protection benefit of cogeneration. There are 400,000 small furnaces and approximately 290,000 smoke stacks in China. Most of them have very poor thermal efficiency (50-55 percent). They are equipped with little or no ash handling equipment. The smoke stacks are low (20-40 m) and smoke is discharged at low altitude to cause serious pollution in urban areas, especially in industrial zones. Based on the situation of existing or soon to be completed cogeneration plants, they more or less can replace under 50 percent of the small furnaces and smoke stacks in the local area. Since cogeneration plans use a venturi-wet membrane type ash handling device, which has a 95 percent ash removal efficiency and 15 percent desulfurization efficiency, and their smoke stacks are more than 80 m, dust and soot are treated efficiently and discharged from a higher point. Instead of spreading ash all over the place, it is concentrated at one point for disposal. Thus, the environment can be significantly cleaned up and the discharge of pollutants from cogeneration can meet the "waste solid, water, and gas" discharge standard.

Because of this lack of understanding, there is not sufficient enthusiasm for cogeneration. This becomes a barrier affecting the development of cogeneration.

2. There is a lack of capital to build cogeneration plants. In the past, electric power authorities focused mainly on electric power and had no interest in heat. Government sponsored electric power projects only had funding for electric power development. There was very little or no fund available for cogeneration. Government directed production plans only specified power generator capacity and power to be generated and did not include any heat supply target. Because a cogeneration plant requires a higher initial investment, more users chose to build a small furnace to satisfy the heat load due to funding limitation. Some local governments only considered their electric power needs and built a number of small condensing steam

type thermal power plants. They failed to consider the option that can solve power and heat shortage together. The Energy Conservation Bureau of the State Planning Commission worked hard to provide support from the energy conservation fund. It invested 986 million yuan in the Sixth 5-Year Plan, which is 3.2 percent of the 30 billion yuan earmarked for electric power plant construction. Some 750 MW of cogeneration capacity was put into operation, which is 3.7 percent of the 20,230 MW capacity completed in the Sixth 5-Year Plan. In addition, some industries built a few residual heat power plants and independently owned small cogeneration plants. Various reasons imposed by the system also limited the source of funding for cogeneration.

3. Industry policy is also a problem. Presently, the power grid pays less to receive electricity from small cogeneration plants, especially independently owned cogeneration plants, and charges more to supply power to these users. For example, it costs 0.07-0.11 yuan/kWh to generate electricity for some fertilizer producers who have their own cogeneration plants. On an average, they are paid 0.05-0.55 yuan/kWh to deliver it to the grid and are charged 0.195-0.23 yuan/kWh to use power from the grid. A small plant can lose 1.5-2.8 million yuan per year. Thus, the more power one generates the more money one loses, which adversely affects any enthusiasm to get involved in cogeneration. In order to alleviate the power shortage situation, some businesses worked hard to raise the capital for a cogeneration plant. After it is in operation, the power target is cut back. They receive no benefits from cogeneration. Instead, it becomes a burden.

III. Potential and Condition for Development of Cogeneration in China

In 1987, the entire country produced 13.42 million tons of nitrogen fertilizer. If 50 percent of the fertilizer plants in the country have their own cogeneration power plants, just as in Jiangsu, then the total cogeneration capacity in the fertilizer industry will reach approximately 1,000 MW, capable of generating 5.5 billion kWh of electricity. This is sufficient to supply one-third of the electricity demand for the chemical fertilizer industry. Every year approximately 1.5 million tons of standard coal can be saved to meet the requirement of a 1,000 MW cogeneration power plant. The textile, paper and pulp, chemical fiber, pharmaceutical, food, metallurgy, and chemical industries use a great deal of heat. If one or more businesses can jointly construct a cogeneration plant, just as the industries in Jiangsu did, then all the heat and over one-third of the electric power needs can be solved. By then, the entire country will have an added capacity of 7,300 MW and 40 billion kWh of electricity; 12 million tons of standard coal can be saved every year, sufficient to supply the coal needed for electric power generation by these cogeneration plants. Therefore, by mobilizing suitable industries to get involved in cogeneration, it is possible to supply all the heat and a portion of the electricity needed by these industries without increasing the amount of coal supply.

From the perspective of the 29 provinces, cities and autonomous regions, there are 156 local authorities, 170 local cities, and 2,194 counties (including cities under the jurisdiction of counties). Our economy is growing everywhere and there is a pressing demand for power and heat. On the basis of overall planning, many local authorities have built or are building cogeneration plants in certain industrial areas to centralize the supply of heat. Several examples are given below.

1. Cogeneration Plant in Huinan County, Jilin in the Northeast

The entire county has a population of 367,000. There are eight small plants, including Chemical Plant One (synthetic ammonia 12,000 tons), Chemical Plant Two (ammonium nitrate, sodium nitrite), Chemical Plant

Three (oxalic acid, nitrobenzene, etc.), a paper mill (corrugated paper 2,000 tons/year), a fluffy cotton plant (300 tons/year), a filter plant (300 tons/year), and a soda ash plant (500 tons/year). In addition, we need to heat up 40,000 m² of space. There are 11 small furnaces and 9 smoke stacks, with a total capacity of 63.5 t/h and consuming 67,000 tons of coal annually. In 1990, the maximum heat load is 54 t/h in winter (including 9.6 t/h for space heating) and 36.5 t/h in summer. It is expected to rise to 78.5 t/h in 1995 (including 13.4 t/h for space heating). After design review, a cogeneration plant consisting of two 35 t/h brown coal burning chain driven furnaces, a B3-35 back pressure turbine, and a CB3-35/1015 generator was approved for construction. Its technical economic indicators are shown in Table 4.

Table 4. Technical Economic Indicators of Regional Cogeneration Plants Under Construction

Item	Unit	Huinan, Jilin	Xinchang, Zhejiang	Lingxiang, Hunan	Huxian, Shanxi
Furnace type		2 x 35-39	3 x 35-39	3 x 35-39	3 x 75-54
Unit type		1 x B3-35/5	1 x B3-35/5	1 x CB3-35/16/5	7 x B6-50/5
		1 x CB3-35/10/5	1 x CB/6-35/9	1 x C6-35/10	1 x CC12-52/10/42
Steam capacity	t/h	59.6	76.5	87.3	105
Power plant investment	10,000 yuan	2,070	2,178	2,435	5,621
Heating network investment	10,000 yuan	63	303	362	434
Annual heat supply	GJ	855,011	1,382,716	1,282,890	1,521,483
Annual power supply	10,000 kWh	2,540	4,464	4,252	9,428
Coal consumption for power generation	g/kWh	246	290	415	369
Coal consumption for power supply	g/kWh	259	351	506	423
Coal consumption for heat supply	g/GJ	40.4	44.7	42.3	42.0
Overall thermal efficiency	%	78	68	66	76
Power generation cost	yuan/kWh	0.034	0.063	0.053	0.036
Selling price for power	yuan/kWh	0.125	0.200	0.120	0.120
Cost for heat production	yuan/GJ	4.8	6.9	4.8	4.3
Selling price for heat	yuan/GJ	7.4	10.0	6.0	5.3
Hours of utilization at maximum thermal load	h	5,978	6,000	7,350	4,941
Hours of utilization of power generating facilities	h	5,722	7,200	6,000	
Annual coal consumption	10,000 tons	4.1	7.72	6.56	10.4
Annual coal conservation	10,000 tons	1.65	2.67	3	4.55
Loan payback period	year	9.99	5.4	8.3	9
Return of capital period	year	4	5.1	8.1	5
Capital profitability rate	%	21.2	29.4	14.3	13.7
Internal profit	%	18.1	27.4	17.7	17.9
Investment due to conservation of coal	yuan/ton	650	473	358	1,199
Ash discharge content	mg/m ³	0.05<0.15	<0.15	0.062<0.15	0.07<0.15
SO ₂ discharge content	mg/m ³	0.012<0.15	<0.15	0.131<0.15	<0.15

2. Cogeneration Plant in Xinchang County, Zhejiang in the Southeast

The entire county has a population of 420,000. In 1986 its total gross produce was valued at 560 million yuan and its industrial output is 450 million yuan. There are small textile printing and dyeing plants, paper mills, wineries and breweries, glue plants, etc. Other industries such as hemp weaving plants, oil refineries, electrochemical plants, blanket mills, and hosiery mills will be in production soon. Currently, an electrochemical plant, a woolen mill, a pharmaceutical plant, a silk plant, a glue factory, and a cannery are being constructed. There are 26 small furnaces with a total capacity of 69.5 t/h and 17 smoke stacks. In 1990, the maximum heat load is 84.7 t/h and the minimum 43.3 t/h. After design review, a cogeneration plant with three 35 t/h chain driven furnaces, a B-35 back pressure steam turbine and a C6-35/10 condensing generator was approved for construction. Its technical economic indicators are also shown in Table 4.

3. Cogeneration Plant in Lingxiang County, Hunan in Central China

The total gross product is valued at 300 million yuan and industrial output is at 154 million yuan. It has small industries such as fertilizer plants, paper mills, wineries, tea plants, textile plants, food plants, cloth weaving plants and knitting plants. There are 25 furnaces at a total capacity of 81.5 t/h and 19 smoke stacks. The heat load is 47.1 t/h. In 1990, it is going to rise to 114.8 t/h. After design review, a cogeneration power plant consisting of three 35 t/h chain driven furnaces, a CB3-35/16/5 back pressure turbine and a C6-35/6 steam generator was approved for construction. Its technical economic indicators are shown in Table 4 too.

4. Cogeneration Plant in Hu County, Shanxi in the Northwest

The county has a population of 50,000 and a gross product valued at 620 million yuan. Its industrial output is 450 million yuan. There are small fertilizer plants, chemical plants, food processing factories and textile mills. The total building area is 139,000 m² with a 59,000 m² production area. There are 40 furnaces capable of producing 107 t/h of steam which consume 50,000 tons of standard coal per year. Some 66.4 t/h of the steam is consumed by production and 17.5 t/h is used for everyday use and 13.2 t/h is for space heating. After design review, a cogeneration power plant consisting of three 75 t/h chain driven furnaces, a B6-50/10 back pressure turbine and a CC12/10/1.2 dual draw generator was approved for construction. Its technical economic indicators are shown in Table 4 too.

From Table 4 we find that it is technically feasible and economically beneficial to construct these cogeneration plants. The environment is also benefited. The four counties listed are located in four corners and they more or less have the same condition for building a cogeneration plant. Their economic situation is about average. There are over 1,000 areas that meet this condition. If

cogeneration plants of various sizes can be constructed all over the country, cogeneration capacity can be increased by approximately 10,000 MW and the amount of electricity generated can be increased by 55 billion kWh. Most of the heat and one-third of the power requirements can be met locally. Areas with coal should jump into it and areas without coal have more incentive to get involved. Just by concentrating the fuel for small furnaces and supply it to the cogeneration plant, not only the same heat load can be satisfied but also extra electric power can be generated. The energy conservation and environmental protection results are obvious. Therefore, an important way to promote cogeneration is to mobilize local authorities to build cogeneration plants as they see fit.

IV. Recommendations

1. Enhance Understanding of Cogeneration as a Means of Energy Conservation

Energy has become a critical factor limiting our economic growth. Moreover, this situation is not expected to change before the year 2000. Therefore, it is necessary to widely promote cogeneration in order to inform the leadership that we must insist on both "development and conservation" to solve our energy crisis. We have to increase their sense of responsibility and urgency to build cogeneration plants so that they will include it in the local energy development plan and make it an integral part of the local economic development plan.

2. Widen Conduits for Capital To Develop Cogeneration

In past years, the government spent 400-500 million yuan in the form of low interest loans to support the development of small cogeneration plants through the energy conservation fund. It is recommended that the government continues to spend 200-300 million yuan per year to support the development of cogeneration through the energy conservation fund.

With economic growth, cogeneration plants should be built in densely industrialized areas with a thermal load of over 20 t/h and a heat utilization time of over 4,000 hours. If half of the local areas have cogeneration plants constructed by 2000, this corresponds to 10,000 MW of added capacity and will require 40 billion yuan in capital; 50 percent or more of the capital will have to be raised locally and the balance will be supported by the central government in the form as low interest loads.

Various departments, especially textile, paper making, chemical fertilizer, chemical fiber, pharmaceutical, sugar making, food processing and metallurgy industries, should jointly build cogeneration plants. It is expected that this type of new cogeneration plants will add 7,500 MW of capacity by 2000 and will require 30 billion yuan in capital. Sixty percent will be raised by industry and the balance will be supplied by the government as low interest loans.

Heating has become an important aspect of urban modernization in medium and large-size cities in China.

Construction of medium and large-scale cogeneration plants should be accelerated on the basis of comprehensive urban planning, based on industrial production and space heating requirements in the north and on industrial heating and cooling needs and hot water heating requirement in southern, central, eastern and southwestern China. It is expected that 5,000 MW of urban and regional cogeneration capacity will be added by 2000 and will require 20 billion yuan of capital. Fifty percent of it will be raised by cities and the remaining will be subsidized by the government.

Based on the above projection, 22,500 MW of cogeneration capacity will be completed by 2000 and the total cogeneration capacity will reach 29,500 MW. This is around 15 percent of the thermal power generation capacity by then. Some 165 billion kWh of electricity will be generated and over 60 million tons of standard coal can be saved annually.

3. Provide Incentives for Developing Cogeneration

Various local governments, especially energy related departments such as power and coal authorities, should support the construction of cogeneration plants. Based on some temporary regulation issued by the State Council regarding the development of small thermal power plants and comprehensive utilization of energy resources, they should let small cogeneration plants link to the power grid. Excess power should be allowed to be sold independently on its own network. Or, it may be delivered to the thermal power grid to be sold by the power authority (with a fixed management fee). Prices must be fixed reasonably. It should reflect quality and peak usage. However, we have to make cogeneration profitable so that it has the ability to pay back the loan and to grow on its own. Upon completion of a cogeneration plant, it is not included in the national power distribution plan. The original power quota assigned to that business or local government will not be reduced in order to encourage everyone to get involved in cogeneration to alleviate power shortage, conserve energy and protect the environment.

4. Strengthen the Production and Supply of Cogeneration Equipment and Accessories

The production capacity of cogeneration equipment and availability of accessories cannot meet the demand in the event of vigorous development of cogeneration. Power generators are primarily manufactured at Harbin, Dongfang, Shangqi and Beizhong Motor Works. There are a few smaller plants in Wuhan, Qingdao, Nanjing and Hangzhou. According to the Seventh 5-Year Plan, 43,000 MW of power generating equipment will be manufactured domestically and approximately 600 MW is for cogeneration. This is merely 7 percent of the capacity manufactured for thermal power generation. In order to achieve the goal of developing cogeneration vigorously, 2,000 MW of cogeneration facilities will have to be supplied. In order not to affect the supply of power generating equipment for large thermal power plants, we

will have to accelerate the reform of production facilities in Qingdao, Wuhan, Nanjing and Hangzhou in order to improve productivity and availability of accessories.

Increase Seen in Electricity Production Investment

*40100028A Beijing CHINA DAILY
in English 12 Feb 90 p 2*

[Article by Zhang Yu'an]

[Text] Investment in electricity will be increased this year in order to inject more energy into the national economy, which has been restrained by energy shortages for over 10 years.

The planned investment managed by the State Energy Investment Corporation—China's major energy investor—is set at 13.82 billion yuan (\$2.94 billion).

Last year's investment was 12.4 billion yuan (\$2.64 billion), said an official of the corporation, who declined to be identified.

The corporation, directly under the leadership of the State Council, was established in July 1988 as a major step in reform of China's investment system.

The official predicted that new electricity projects this year will have a total capacity of about 8.5 million kilowatts, including 4 million kilowatts of hydro-electricity.

The Ertan Hydro-Power Station in Sichuan Province, on which construction is scheduled to start this year, will have a capacity of 3.3 million kilowatts, which would make it the biggest hydro-station in China, he said.

The project will also mean that the corporation's total energy capacity under construction this year will jump to over 40 million kilowatts, the official said.

He said that the corporation's policies for this year are to give priority to construction of hydro-power stations due to the coal shortage and to maintaining the scale of construction scales in order to realize a steady growth in the energy resources industry.

By the end of this year, about 3.76 million kilowatts of power, generated by 22 hydro- and thermo-electricity projects, are expected to be made available for production use.

"This will help to ease the energy shortage condition and support the development of the national economy," the official said.

In the past four years, the electricity industry developed faster than the economy as a whole, with an average annual growth rate of 8.6 per cent.

That was 2.6 per cent higher than planned, the official said.

Thus, the Seventh Five-Year Plan (1986-90) for the electricity industry was fulfilled one year ahead of schedule, he said.

By the end of last year, the country's electricity generating volume was over 570 billion kilowatt-hours, surpassing the planned 550 billion kilowatt-hours set for 1990.

The total capacity of installed electricity generators was 124 million kilowatts, also surpassing the plan set for 1990.

This year's electricity generating volume and capacity of installed electricity generators will be 600 billion kilowatt-hours and 130 million kilowatts respectively, the official said.

However, compared to demand, electricity supply is still lagging behind.

So the corporation plans to take measures to keep a steady growth in investment in China's energy resource industry in order to support national economy development.

Energy resource projects invested by the corporation are about two-thirds of the country's total.

China's 100 Experimental Counties in Rural Electrification

906B0003C Beijing SHUILI FADIAN [WATER POWER] in Chinese No 8, Aug 89 pp 52-53

[Article by Li Ying [2621 3576] and Ma Baoying [7456 1405 3841] of the Ministry of Water Resources Rural Electrification Department: "Development Situation for Small-Scale Hydropower and Rural Electrification Trial Counties in China"]

[Text] China's 100 trial rural electrification counties which receive power supplies primarily from small-scale hydropower have developed substantially in the following areas.

1. Progress in power source construction is relatively fast and they have almost attained plan requirements. At the end of 1988, the trial counties had completed an installed generating capacity of 2,223 MW, equal to 73 percent of the plan. If 723 MW in power stations under construction is included, the total of 2,946 MW, equal to 97.2 percent of the plan. The requirements of elementary rural electrification standards call for a gradual shift in power source construction from the problem of building too many runoff power plants in the past to beginning to add several key reservoirs and hydropower stations with regulation capabilities and for using the development of small-scale hydropower in regions having the proper conditions to solve the problem of inadequate power during the dry season.

2. There has been a gradual improvement in the deployment of grids and a continued increase in benefits. In the past, grids developed slowly in regions of small-scale hydropower, causing a lack of matchup between power generation, supplies, and use, and making it hard to take advantage of the benefits. Now, on the basis of electrification plans for active development of power transmission and transformation projects, a total of 313,000 kilometers of high and low voltage power transmission lines had been completed by the end of 1988, equal to 91.5 percent of the plan and an increase of 20.4 percent over 1987. The total power transformation capacity was 6,009 million kVA, equal to 75.9 percent of the plan. In the areas of power transmission and transformation, particular attention has been given to improving the deployment of grids, and the average number of 35 kV power transformer sites for each county has increased from 3.1 to 5.6, for gradual achievement of coordinated development of power generation, supply, and use. Stronger grid coordination has increased benefits rather quickly. Average gross profits for electric power enterprises in each county have grown from 820,000 yuan before the trials to 1.88 million yuan, a 1.29-fold increase.

3. There has been a focus on relying on one's own efforts to raise capital from many sources for electrification construction. Besides the 100 million yuan in state capital subsidies (loan allocation and revision) for electrification construction each year, the 100 counties have

also adhered to the policy of "using power to develop power." They have implemented capital raising from many channels and many levels. Total investments of 696 million yuan were completed in 1988. This included 455 million yuan or 65.3 percent in power source construction and 241 million yuan or 34.7 percent in grid construction. In the construction, all counties mobilized the masses and enterprises to invest labor and raise capital and used a total of 274 million yuan in capital raised by using power to develop power, equal to 39.4 percent of investments for 1988 as a whole. This fully embodied the enthusiasm of all counties for building rural electrification.

4. Greater power use in rural areas has promoted development of industrial and agricultural production. In 1988 these 100 counties used a total of 6.28 billion kWh of electricity, an increase of 14.78 percent over 1987. Per capita power utilization for the year was 184.5 kWh, a 1.28-fold increase over the pre-trial figure of 81 kWh. The spread of power utilization and higher guarantee rates have promoted development of industrial and agricultural production. The gross value of industrial and agricultural output in the 100 counties was 24.62 billion yuan in 1988, an increase of 95.1 percent over the pre-trial period. This includes a 2.66-fold increase in the gross value of industrial output and a 4.48-fold increase in the value of output in township and town enterprises. The gross value of industrial output as a proportion of the gross value of industrial and agricultural output increased from the pre-trial figure of 32.7 percent to 54.82 percent, and the value of industrial output accounted for more than 50 percent of the gross value of industrial and agricultural output in 51 of the counties. This has effectively promoted a shift from the predominance of agriculture to the predominance of industry in the rural industrial structure. At the same time, it has led to a shift of rural labor power. Preliminary statistics indicate that over 3.02 million rural laborers in the 100 counties shifted into secondary and tertiary industries over the past 5 years. There also was a 20 percent increase in the drainage and irrigation area and grain output grew by 18 percent.

5. The rapid spread of rural power use has promoted construction of material civilization and spiritual civilization. The number of households in the 100 counties which had electric power reached 6,786,900 at the end of 1988, equal to 90.85 percent of total households. The household electricity availability rate exceeded 90 percent in 72 counties. The universal spread of power use has promoted construction of material civilization and spiritual civilization. During the 5-year period, 10.08 million peasants in mostly mountainous regions stopped using oil lamps and pine branches for illumination and using manual labor to grind flour and thresh rice, attaining light and happiness brought about by electrification. The spread of electricity also has promoted development of culture and education and televisions have rapidly entered rural households. Changbai County, located on the Sino-Korean border, has inconvenient communications. Construction of electrification

has provided 99.9 percent of peasant households with power. On the average, there is one television for every 1.9 peasant households in the county. This has greatly reduced discrepancies between urban and rural residents, opened their horizons, provided them with news, and improved their cultural quality. Preliminary statistics indicate that annual per capita net income in the 100 counties has risen from 198 yuan before the trials to 500.95 yuan, and Changbai County has reached a per capita average of 1,100 yuan.

6. The "standard" has been attained by 48 counties. By 1988, a total of 48 counties had passed project specification examinations during on-site visits by relevant departments organized by provincial (autonomous region) people's governments in accordance with elementary rural electrification county standards issued by the Ministry of Water Resources and Electric Power. Table 1 shows the installed generating capacity, yearly power output, and yearly power use for these counties. Projections are that all 100 counties will attain elementary rural electrification county standards during 1989.

Table 1. Installed Generating Capacity, Yearly Power Output, and Yearly Power Use for 48 "Elementary Rural Electrification Counties" in 1988

Province	County (city)	Installed generating capacity (kW)	Yearly power output (10,000 kWh)	Yearly power use (10,000 kWh)	Province	County (city)	Installed generating capacity (kW)	Yearly power output (10,000 kWh)	Yearly power use (10,000 kWh)
Fujian	Yongchun	29,205	10,026	10,786	Guangxi	Xinchang	33,222	9,266	12,099
	Yongning	47,654	21,400	11,295		Jinyun	17,009	6,902	7,014
	Minqing	29,580	10,035	9,902		Qingyun	15,405	6,034	5,862
	Guangze	21,692	6,743	8,252		Shengxian	29,950	9,195	16,290
	Longxi	40,718	13,995	12,311		Guanyang	19,383	6,584	4,547
Guangdong	Longmen	38,977	10,468	8,308	Yunnan	Hexian	34,757	13,473	14,334
	Qujiang	27,895	8,599	10,652		Gongcheng	22,188	6,024	6,405
	Renhua	26,444	14,467	9,465		Daxin	17,999	6,651	6,013
	Xinfeng	31,408	11,645	6,867		Yuanjiang	25,026	11,573	15,123
	Pingyuan	22,245	7,230	7,880		Huaning	18,511	4,441	3,370
Hunan	Jiaoling	17,665	6,757	7,963	Luxi	Luliang	31,890	7,033	13,511
	Ruyuan	33,702	12,500	8,938		Chengjiang	19,230	2,670	5,218
	Yangshan	16,300	17,510	9,800		Chengjiang	10,150	3,389	7,265
	Lingxian	29,208	8,799	6,578		Zhongdian	10,795	2,590	2,283
	Qianyang	31,323	11,604	8,992	Hubei	Tongcheng	22,218	4,640	6,285
Sichuan	Chengbu	18,869	6,030	5,194		Jianshi	33,552	8,070	7,207
	Dayi	25,884	17,260	12,440		Xingshan	35,045	13,757	7,471
	Hongya	43,031	19,905	5,768		Fengxin	20,400	7,930	5,548
	Duijiang Yan	44,276	24,100	20,175		Wuyuan	20,983	5,826	4,463
	Wenchuan	12,900	5,430	4,231		Dexing	17,975	4,810	4,080
Zhejiang	Yingjing	17,332	8,863	3,311		Yifeng	11,904	3,747	3,985
	Emei Shan	23,476	9,170	11,223		Dayu	12,660	4,568	3,296
	Ebian	12,777	7,252	3,114		Jing'an	6,901	2,684	1,972
	Yunhe	5,938	1,926	3,495	Jilin	Changbai	26,766	5,017	4,016

7. Work in the trial counties has promoted development of small-scale hydropower throughout China. The impetus of the trial counties has led to new advances in small-scale hydropower construction. The scale of small hydropower now under construction in China is 3,000 MW. The total installed generating capacity for hydropower in China at the end of 1988 was 11,790 MW, about one-third of the hydropower installed generating capacity in China. There was an addition of 790 MW in installed generating capacity in 1988 and yearly

power output of 31.6 billion kWh. The yearly average equipment utilization time reached 2,820 hours, a substantial increase over 1987. Table 2 lists the small-scale hydropower installed generating capacity, power output, and utilization time situation for all provinces, municipalities, and autonomous regions in China. Over 2.2 million kilometers of high and low voltage matching power transmission lines have now been completed in regions which receive their power supplies from small-scale hydropower and the power supply and matching

power transformation capacity has reached 4,441 kVA. These facilities provide power supply conditions for one-third of the counties and 36 percent of the townships in China. Small-scale hydropower construction has played a positive role in alleviating the rural power shortage and promoting construction of material and spiritual civilization in rural areas.

Table 2. Small-Scale Hydropower Development Situation for All of China's Provinces, Municipalities, and Autonomous Regions

Province, municipality, or autonomous region	Installed generating capacity (10,000 kWh)	Yearly power output (100 million kWh)	Average yearly utilization time (hours)
Total for China	1,179.23	316.08	2,820
Guangdong	174.13	48.86	2,895
Sichuan	148.52	55.24	3,974
Hunan	116.87	31.71	2,829
Fujian	110.60	37.07	3,529
Yunnan	89.24	20.82	2,704
Guangxi	82.29	20.68	2,652
Hubei	75.03	17.07	2,350
Zhejiang	70.34	16.99	2,499
Jiangxi	63.38	15.80	2,593
Guizhou	43.21	8.86	2,153
Xinjiang	36.47	9.68	2,707
Henan	23.85	3.49	1,483
Hainan	18.29	3.54	2,049
Gansu	14.37	4.02	2,846
Jilin	13.85	3.80	2,793
Shaanxi	12.66	2.80	2,296
Hebei	12.18	1.76	1,519
Tibet	11.91	2.33	2,063
Anhui	10.71	1.88	1,871
Shanxi	9.16	1.71	1,907
Shandong	7.69	0.33	434
Liaoning	7.46	1.73	2,403
Qinghai	6.47	1.93	2,958
Heilongjiang	6.33	1.97	3,241
Beijing	4.87	0.61	1,250
Jiangsu	3.07	0.41	1,351
Inner Mongolia	3.01	0.59	1,965
Ningxia	0.6	0.12	1,938
Tianjin	0.5	0.001	—
Under jurisdiction of Ministry of Water Resources	2.16	0.28	1,296

Note: Figures in the table do not include Taiwan Province

Development of Medium-Sized Hydropower Stations

906B0003B Beijing SHUILI FADIAN [WATER POWER] in Chinese No 8, Aug 89 pp 7-8

[Article: "‘Concerning Methods To Accelerate Small-Scale Hydropower Development’ Formally Printed and Distributed by Ministry of Energy Resources"; first paragraph is SHUILI FADIAN introduction]

[Text] Pushing forward with construction of several medium-scale hydropower stations in the near term is an important part of China's plans to increase electric power before the year 2000. For this reason, the Ministry of Energy Resources formulated "Concerning Ways To Accelerate Small-Scale Hydropower Development" and formally printed and distributed it on 19 May 1989. While checking and approving the "Methods," State Council member Comrade Zou Jiahua [6760 1367 5478] gave the following instruction concerning the development of all of China's hydropower construction: "By holding steady for 10 years and not relaxing, trying to place 4,000 to 5,000 MW into operation yearly, and adding thermal power, nuclear power, and energy resource conservation, it may be possible to reduce the electric power shortage somewhat after 10 years." We are now publishing the "Methods" in their entirety to facilitate their implementation. Relevant departments in all areas which have opinions during implementation should immediately notify the Ministry of Energy Resources.

To resolve the contradiction between supply and demand for electric power and speed up development of hydropower resources, accelerated construction of large-scale hydropower stations now under construction should be combined with accelerated construction in the short term of several medium-scale hydropower stations which have short construction schedules, produce results quickly, conserve investments, are technically simple, and have relatively small inundation losses and superior indices in regions which lack coal resources but do have hydropower resources. This is an important part of China's plans for adding electric power prior to the year 2000.

Construction of medium-scale hydropower stations conforms to industrial policies formulated by the State Council and raising capital for construction can motivate the initiative of all areas to develop power. Widespread absorption of social capital within policies stipulated by the state can aid in readjustment of the state economic structure.

1. The construction system: The principle is that those who invest in medium-scale hydropower stations should be the ones who use the electricity and receive the profits. Local investments usually are the most important, and they are treated as local projects and included in provincial (municipality or autonomous region) construction plans, with provinces (municipalities or autonomous regions) being responsible for construction. Departments, localities, and enterprises can enter as stockholders and make loans, with property rights belonging to stockholders.

2. Medium-scale hydropower plans should conform to the needs of river basin plans for the rivers on which the power stations are located, and they should be included in electric power plans of electric power departments in all regions.

3. Administration and management: Units which raise capital can organize a board of directors or management commission (under the unified name of proprietors). The proprietors can directly organize management organs to carry out operational management themselves. They also can have the proprietor entrust electric power departments or other qualified organs with management for signing contracts to implement a separation of ownership rights and management rights, with each having their own responsibility. They also can organize medium- and small-scale river basin or regional hydropower development companies for unified management of power station construction and administration. If a power station operates connected with a grid, it must sign a power sales contract with the grid management department. Regardless of who operates and manages it, the power station must serve unified regulation in the grid and assure safe operation. With a prerequisite of guaranteeing rational profits for the investors, it should strive to optimize economic results. In regions not covered by large grids, medium-scale hydropower stations can supply power directly to users.

4. Capital raising: Using mainly local capital construction funds, requisition an electric power construction fund of 0.02 yuan per kWh from power output for preferential use in hydropower construction (including preparatory work). We can absorb capital from enterprises in all areas which use electricity, capital owned by electric power departments in all areas, state construction funds from the State Energy Resource Investment Company, investments from shares bought for comprehensive benefits, shares bought by local land occupation and reservoir inundation loss mortgages, shares bought by the China Energy Group, hydropower construction enterprises buying shares by taking responsibility for construction, design units using design fees to buy shares, equipment manufacturing plants buying shares with equipment, shares bought by bank loans and stocks or bonds handled by banks within the scope of state policy stipulations, and so on. With a prerequisite that a province should have foreign exchange and be able to repay the foreign exchange, they can borrow and repay

their own foreign investments and include them in state foreign exchange utilization plans.

5. Concerning electricity prices: In accordance with the spirit of State Council Document No 72 (1988) "Concerning Printing and Distributing Notices for Electric Power Industry Management System Reform Programs" and Document No 72 (1985) "Provisional Regulations Concerning Encouragement of Capital Raising To Develop Power and Implementation of Multiple Types of Electricity Prices," newly built medium-scale hydropower stations should practice independent accounting and implement seasonal and peak-valley electricity price differentials. Import market mechanisms to set core electricity prices, sign power supply contracts with users, and give power stations the capacity to repay loans and a self-development capability.

6. Reservoir region policies for medium-scale hydropower can be decided upon by local government commercial departments. After the power stations are completed, they should set aside a specific reservoir region economic development fund from the income from electricity sales for developing production in the reservoir region to ensure a stable capital source for developing production in the reservoir region.

7. Establishing projects and applying for approval: For medium-scale hydropower capital construction projects under provincial jurisdiction, the state can handle them by stipulating project establishment and approval application procedures for capital construction projects. The category established for medium-scale hydropower is still stipulated as 25 MW to 250 MW. To avoid mistakes in decisionmaking, provincial level governments are responsible for organizing electric power, water conservancy, and hydropower departments to participate in examining feasibility research reports and preliminary designs for projects of less than 100 MW and for reporting their ratification to the Ministry of Energy Resources. Provincial level governments should meet with the Ministry of Energy Resources for joint examination of feasibility research reports and preliminary designs for projects of 100 to 250 MW.

8. Reference standards for preferential project establishment: 1) Passing examination of the feasibility research report. 2) A unit investment of less than 2,500 yuan per kW. 3) Serious coal and power shortages in the region to be supplied with electricity. 4) Regions to be supplied with electricity are in poor areas. 5) Simple engineering, good construction conditions, short construction schedules, and an ability to assure power generation within 3 years. 6) Small reservoir inundation losses, large environmental capacity in the reservoir region, and no residual problems. 7) Yearly utilization time generally no less than 3,000 hours. 8) Implementation of capital raising and a loan repayment capability. 9) Implementation of load requirements.

9. Focus on building medium-scale hydropower projects now under construction, strive to shorten construction schedules, assure project quality, and strive to provide benefits as quickly as possible.

10. Request that planning commissions in all provinces (municipalities and autonomous regions) make electric power departments, hydropower offices, and relevant units responsible for reinforcing preparatory work for medium-scale hydropower, with localities raising the preliminary costs and repaying them from the investment after project construction begins. Formulate medium-scale hydropower development plans for their own provinces and include them in electric power plans for their province. After preliminary examination of near-term and medium-term development plans, provincial planning commissions should be requested to report them to the Ministry of Energy Resources before September 1989.

Sichuan Should Be Developed Into Hydropower Base

906B0003A Beijing SHUILI FADIAN [WATER POWER] in Chinese No 8, Aug 89 pp 3-7

[Article by SHUILI FADIAN reporter: "Gradually Build Sichuan Province Into China's Main Hydropower Base Area—A Record of a Comprehensive Investigation of Sichuan Province's 'Three Rivers'"]

[Text] Ten years ago, the former Ministry of Electric Power Industry proposed the idea of building 10 large hydropower base areas in China on the basis of existing river basin plans and survey and design work. A preliminary scale has now been achieved in some of these 10 large hydropower base areas in the past 10 years while work has just begun on others. This latter group includes the three large hydropower base areas on the Yalong Jiang, Dadu He, and Jinsha Jiang in Sichuan Province where relatively little work has been done to start building power stations. Sichuan Province has a vast area, large population, and abundant resources, especially hydropower resources, in which it is the leader in China. During modernization and construction, Sichuan Province's lack of oil, small amount of coal, limited natural gas reserves, and electric power shortages have severely restricted development of its national economy. Developing Sichuan's rich and advantageous hydropower resources and providing sufficient high quality electric power is enormously important, both for its huge promoting role in socioeconomic development in Sichuan at the present time and for future development strategies and the provision of stronger electric power to the east China region. For this reason, the Sichuan Provincial Government invited the China Hydroelectric Power Engineering Society, China Energy Resource Research Society, and China Water Conservancy Economics Research Society (abbreviated below as the three societies) to conduct a comprehensive investigation of the Jinsha Jiang, Dadu He, and Yalong Jiang (abbreviated below as the Three Rivers). In mid-April

1989, the investigation group composed of several 10 experts, scholars, and reporters from throughout China in coordination with leaders, experts, and scholars from the relevant units and departments in the Sichuan Provincial Government and with Comrades Lin Hua [2651 5478] and Luo Xibei [5012 6007 0554] as group leader and deputy leader spent 40 days making a comprehensive economic investigation of the Three Rivers focused on hydropower. The investigation group surveyed over 20 hydropower station dam sites and the economic development situation in several cities (counties). Everyone saw clearly that there had been substantial development of Sichuan's national economy and social production since the 3d Plenum of the 11th CPC Central Committee, with Sichuan's GNP reaching 89.5 billion yuan in 1988 and efforts to increase it to 215 billion yuan by the end of this century. However, economic and social development in Sichuan Province is now being hindered by stagnant growth in the electric power industry. If this restriction is not solved soon, it will seriously affect achievement of present and future strategic development goals. The investigation group analyzed Sichuan's energy resources and its communications and transportation to the outside. They felt that the keys to invigoration of Sichuan's economy were taking full advantage of its abundant hydropower resources and major efforts to develop hydropower. This is particularly true for the Three Rivers region, which is second in China in iron ore resources and accounts for 93 percent and 64 percent, respectively, of China's titanium and vanadium. It also is rather rich in copper, phosphorous, sulfur, and other rare metals as well as marble, asbestos, and other resources, so it is truly southwest China's "golden triangle." Full utilization of the hydropower resources of the Three Rivers and gradual completion of three big hydropower base areas is essential to provide the conditions for major development of iron and steel, nonferrous metals, the chemical industry, and the construction materials industry to convert hydropower advantages into economic advantages. Here, we will provide a comprehensive description of Sichuan Province's current energy resource situation, hydropower advantages, hydropower base area construction, medium-scale hydropower development, and other questions.

I. Sichuan Province Is Facing Severe Shortages of Both Power and Coal

Sichuan has had a sustained power shortage for over 10 years now. It has intensified in recent years and has become a factor which restricts development of Sichuan Province's national economy and social affairs. Sichuan Province added just 270 MW in new installed generating capacity during the Sixth 5-Year Plan, a mere 1.4 percent of the capacity placed into operation in China over the same period. The installed generating capacity in Sichuan at the end of 1988 was 6,000 MW (including 3,060 MW in hydropower) with yearly power output of 29.7 billion kWh. There is now a power shortage of about 1,500 to 1,700 MW during the dry season and a yearly power shortage of about 7 billion kWh. The lost industrial and agricultural value of output due to shutdowns

because of the power shortage now exceed 2 million yuan annually and 30 percent of existing industrial production capacity cannot be utilized. During the dry season most industrial enterprises can only "shut down for 3 days and run for 4," "shut down for 4 days and run for 3," or even "shut down for 5 days and run for 2." There are no guarantees for urban and suburban household power supplies and the power supply situation in rural areas is even worse. Thus, there is an urgent need to develop electric power construction in Sichuan and we should strive to move forward with it first if we want to attain sustained, stable, and coordinated development of Sichuan Province's national economy.

Sichuan Province has a relative shortage of coal resources. Sichuan had total proven coal reserves of 12.97 billion tons at the end of 1987 and recoverable reserves of 9.607 billion tons, just 1.2 percent of China's total reserves. Some 3.692 billion tons are now being extracted and utilized, equal to 38.43 percent of total reserves. The distribution of Sichuan's coal reserves is such that most is located in south and east Sichuan while west and north Sichuan have relatively few resources. Although coal output in Sichuan Province has grown at a 7 percent annual growth rate over the past few years, the rapid development of all sectors of the national economy, particularly the electric power and other industries, has led to growing shortages of coal and a decline in stocks which is frequently manifested in emergency shutdowns of power plant generators and production stoppages at plants because of inadequate coal supplies. There are no guarantees for coal supplies contained in municipal people's government plans in Chengdu and Chongqing. Even more serious is that no arrangements have been made for fuel sources for the new Jiangyou (670 MW), Chengdu (200 MW), Luohuang (670 MW), Huangjuezhuang (400 MW), and other thermal power plants now under construction. Preliminary estimates are that Sichuan will have coal shortages of as much as 5 to 7 million tons in 1990, 18 million tons in 1995, and 25 million tons in 2000. Moreover, annual coal use in new thermal power plants built before 2000 will be 18.03 million tons. Although Sichuan Province accounts for nearly one-half of total yearly output of other energy resources like natural gas in China, its reserves are limited. Petroleum reserves are unclear and output is extremely small. Thus, the only way out for electric power construction in Sichuan is a major effort to develop hydropower, and hydropower resources are precisely Sichuan's largest developable energy resource advantage.

II. Hydropower Resources Are Sichuan's Advantage

China has a developable hydropower installed generating capacity of 378,000 MW and yearly power output of 1.92 trillion kWh, first place in the world, but only about 6 percent has been developed so far, the lowest for any nation in the world. Sichuan holds first place in China's extremely abundant hydropower resources with 91,660 MW of developable resources for a yearly power output of 515.3 billion kWh, equal to 27 percent of the

total for China. However, just 2.7 percent had been developed up to the end of the Sixth 5-Year Plan, which is much lower than the national level. It is apparent from this that China's hydropower resources, particularly Sichuan's hydropower resources, come far from attaining the necessary degree of development and rational utilization.

Hydropower resources are Sichuan Province's advantage. One can truly say that it has many river basins and that "jewels" can be built at many sites. Statistics show that Sichuan has 1,380 large, medium, and small river basins which cover more than 100 square kilometers including 380 with hydropower reserves of more than 10 MW. The results of planned site selection show 29 sites where large power stations over 1,000 MW can be built and 34 sites for large-scale power stations of 250 to 1,000 MW. The total capacity of these two categories of power stations is 74,000 MW, equal to 80 percent of Sichuan's developable hydropower resources. There are 351 sites for medium-scale power stations of 10 to 250 MW with a total installed generating capacity of 16,000 MW, about 18 percent of developable hydropower resources. There are 648 sites for small-scale power stations of 500 kW to 10 MW with a total capacity of 1,510 MW, equal to 2 percent of developable hydropower resources.

Sichuan Province's hydropower resources are characterized first by a majority of river sources being located in the mountains and gorges of west and northwest Sichuan which have abundant rainfall and snowfall and comparatively stable runoff, with little difference between flow rates in the wet and dry seasons. This is extremely favorable for building hydropower stations or comprehensive utilization key water conservancy projects. Second, there are widely distributed large, medium, and small-scale power stations, most of which can serve as power sources, which benefits integrated development of large, medium, and small scales.

A primary reason for the continued very low extent of hydropower resource development in Sichuan (as well as all of China) is inadequate understanding and concern for hydropower development. It is always felt that hydropower stations cost more and take longer to build than thermal power plants so hydropower is not economically feasible. Moreover, building thermal power plants can provide a quick solution to our electric power shortage. Actually, if the investment and time involved in opening coal mines and transport capacity is included in the calculations, there is not that much difference between hydropower and thermal power in the investment per unit capacity and engineering and construction schedules. Moreover, hydropower resources are renewable energy resources with the combined advantage of developing primary energy resources while simultaneously completing secondary energy resources. Coal and oil consumes energy resources, and a ton used is one less ton available. Thus, it is extremely important that hydropower and thermal power be developed according to local conditions. Given the amount of developable hydropower energy resources in Sichuan, there is no

doubt that electric power construction should implement the principle of a focus on hydropower along with simultaneous development of hydropower and thermal power and integration of large, medium, and small scales. Only in this way can we take full advantage of Sichuan's hydropower resources. It should be explained here that when building hydropower stations, we cannot neglect building the necessary thermal power plants or developing and utilizing other energy resources. This can solve the problems of inadequate power supplies from hydropower during the dry season and mutual regulation. After confirming the electric power construction principle of a focus on developing hydropower, there should be a comprehensive macro plan for hydropower development in Sichuan and a time sequence plan for developing all river basins and hydropower stations to benefit faster preparatory work, site selection, and continual development.

A major effort to develop Sichuan hydropower can guarantee power supplies for industry and agriculture in Sichuan and it can achieve the plan for "transmitting power from west to east China," alleviate the electric power shortage in the economically developed regions of east China, reduce the danger of flooding in the upper and middle reaches of the Chang Jiang, and provide favorable conditions for developing irrigation and water-borne transport, timber floating, breeding, and so on.

III. Gradually Build Sichuan Province Into China's Main Hydropower Base Area

The segment of the Yalong Jiang between its two mouths and Panjihua, the segment of the Dadu He between its two mouths and Tongjiezi, and the segment of the Jinsha Jiang between Shigu and Yibin are three of China's already planned 10 developable hydropower base areas. These three rivers have a developable total installed generating capacity of 71,350 MW in hydropower resources within Sichuan's borders and can produce 406 billion kWh of power annually, about 79 percent of developable power output in Sichuan. Of the 29 large-scale hydropower stations in Sichuan larger than 1,000 MW, 26 are located in these three river basins. Thus, planned construction of several large and medium-scale hydropower stations on these rivers and their tributaries could gradually form this powerful hydropower energy resource base area in Sichuan Province. Below, I will briefly describe an overview of these three large hydropower base areas, recommendations by the investigation group concerning intensive implementation of preparatory work, and points for beginning construction during the Eighth 5-Year Plan.

1. Yalong Jiang Hydropower Base Area

The Yalong Jiang is the largest tributary of the Jinsha Jiang in the upper reaches of the Chang Jiang. It runs for a total length of 1,582 kilometers (1,360 kilometers within Sichuan), has a river basin area of 130,000 square kilometers, and a yearly flow of 59.1 billion cubic meters, equal to 13.3 percent of the upper reaches of the

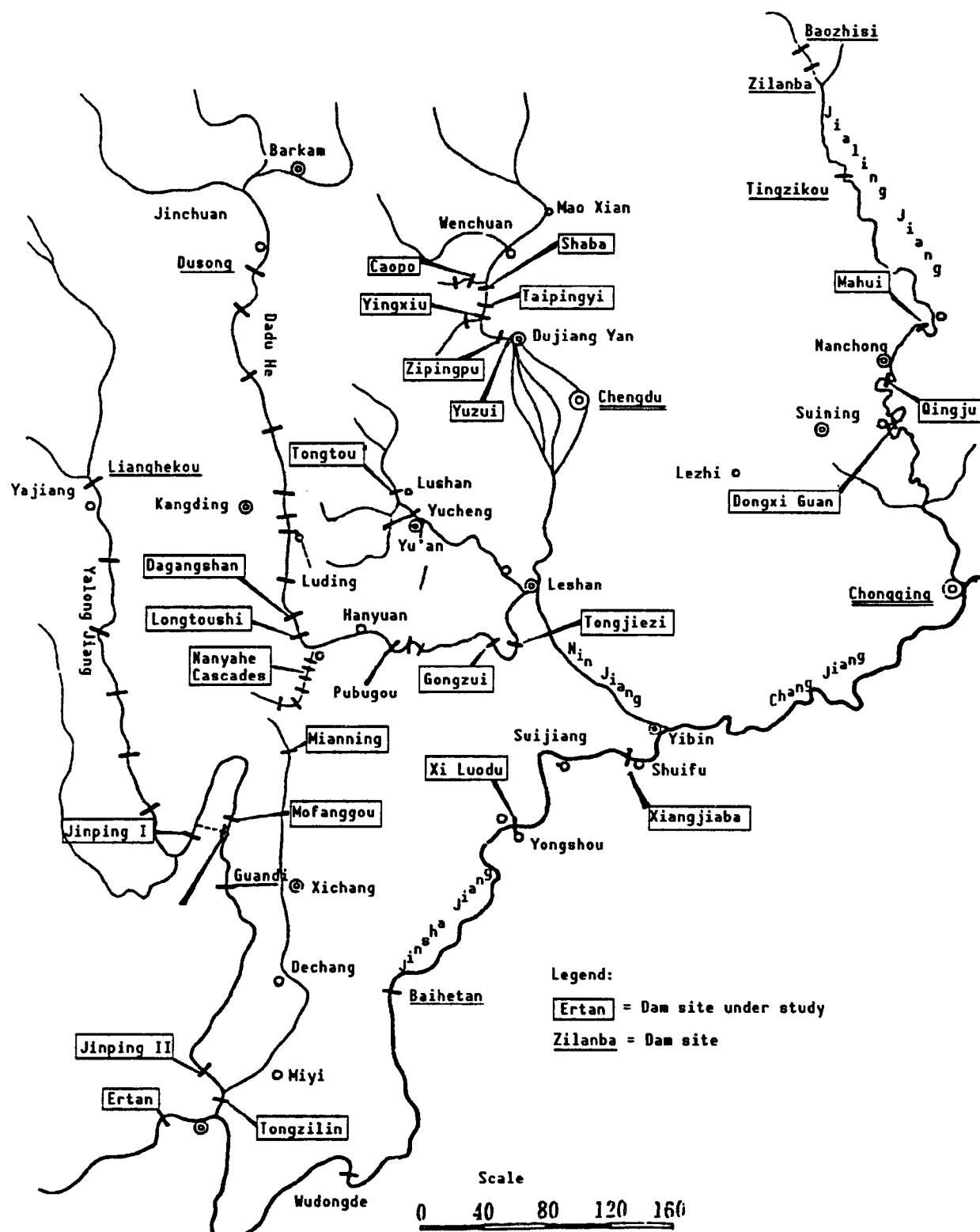
Chang Jiang. The Yalong Jiang has abundant flow and a concentrated head, with hydropower resource reserves of 33,440 MW within Sichuan's boundaries, 24,910 MW of it developable. A total of 11 cascades have been planned for the section of the river between its two mouths on the Chang Jiang and Panjihua. These include four cascade hydropower stations at the Jinping first cascade (3,000 MW) and Jinping second cascade (3,000 MW) on the Yalong Jiang at the site of Dahe Bay at Jinping Shan and at Ertan (3,300 MW) and Tongzilin (400 MW) in its lower reaches which should be the focus of medium and short-term research and development.

Ertan Hydropower Station, a first-period project in cascade development of the river segment in the lower reaches of the Yalong Jiang, is more than 40 kilometers from Panjihua City. The installed generating capacity of this power station is 3,300 MW with yearly output of 17 billion kWh, which are superior technical economics indices. This project was included in the Seventh 5-Year Plan and 1987 state capital construction plan, and preparations for construction have now begun. Projections indicate that all the preparatory work may be completed during 1989, construction will begin in 1990, two generators (1,100 MW) will begin producing power in 1997, and construction will be completed in 1999. Completion of Ertan Hydropower Station can reduce the severe power shortage in Sichuan and promote further development and comprehensive utilization of iron ore, vanadium and titanium resources, and other nonferrous metals in the Panxi region, with extremely apparent economic benefits. The focus now should be on implementing construction funds to enable an early start on construction of the main portion of the project. Tongzilin Hydropower Station downstream from Ertan Hydropower Station is a counter-regulation power station for Ertan. It has an installed generating capacity of 400 MW and yearly power output of 2.5 billion kWh. Communications are convenient at the dam site and there is a large construction area so work to begin building it should start when Ertan Power Station is completed. Because of the complex topography, unclear geological conditions, and extremely difficult communications at the Jinping first and second cascade power stations, geological prospecting work and feasibility research should be speeded up.

2. Dadu He Hydropower Base Area

Dadu He is the largest tributary of the Min Jiang. It is 1,062 kilometers long and has a river basin area of 77,400 square kilometers and a yearly flow of about 49.5 billion cubic meters, equal to 11 percent of the upper reaches of the Chang Jiang. The Dadu He has abundant flow, stable runoff, and a concentrated head, with hydropower resource reserves of 31,020 MW, with 23,370 MW of this amount developable. Dadu He is located in central Sichuan near the main industrial and agricultural power using region of central Sichuan, and has convenient communications. Plans call for a total of 16 cascades in the section of the river between the two river mouths on the trunk and Tongjiezi. This includes

HYDROPOWER



Dam Sites Inspected by a Comprehensive Inspection Group of the "Three Rivers" Area of Sichuan

four cascade power stations near the middle and lower reaches where development conditions are rather superior at Longzui, Tongjiezi, Baobugou, and Dagangshan.

Longzui Power Station (low dam) was completed in 1973. It has an installed generating capacity of 700 MW, guaranteed output of 179 MW, and yearly power output of 3.418 billion kWh. It had generated 45.583 billion kWh up to the end of 1988, equivalent to 2.81 billion yuan in value of output. It is now the main power source in the Sichuan Grid. A program to raise the height of the large dam at Longzui is now being studied. The installed generating capacity at Longzui Power Station after the dam is raised in height will be 2,055 MW, with guaranteed output of 422 MW and yearly power output of 10.1 billion kWh. Construction is now in progress downstream at Tongjiezi Hydropower Station with an installed generating capacity of 600 MW, guaranteed output of 240 MW, and yearly power output of 3.21 billion kWh. If the funds can be guaranteed, projections are that it may begin generating power in 1991. Baobugou Hydropower Station is located in the middle reaches of the Dadu He. It has an installed generating capacity of 3,300 MW, guaranteed output of 918 MW, yearly power output of 14.43 billion kWh, and a total reservoir capacity of 5.04 billion cubic meters, giving it less than year-round regulation capabilities. This power station passed a feasibility research report at the end of 1988. Its completion will solve increasingly serious silt accumulation problems at Longzui Power Station and it will raise the flood prevention standards of the ground surface plant building at Longzui Power Station and increase the guaranteed power output capacity of Longzui and Tongjiezi Power Stations. It also may improve operating conditions in the Sichuan Grid. The biggest problem is the substantial difficulty in dealing with inundation. Baobugou Power Station is one of the large-scale hydropower projects which we will try to begin building in the Eighth 5-Year Plan. Dagangshan Power Station has an installed generating capacity of 1,500 MW and yearly power output of 9 billion kWh. It has shallow river bed, capping strata are shallow, small reservoir inundation losses, and relatively superior development conditions. It is now in the planning stages and I propose that preparatory work be intensified.

3. Jinsha Jiang Hydropower Base Area

The river segment of the upper reaches of the Chang Jiang between Yushu in Qinghai and Yibin in Sichuan is called the Jinsha Jiang. It is 2,300 kilometers long, covers a river basin area of 473,000 square kilometers, and has a long-term average flow rate of 4,610 cubic meters/second and yearly flow of 145.6 billion cubic meters. Jinsha Jiang has an abundant flow and concentrated head. Its hydropower resource reserves within the borders of Sichuan are 30,100 MW, of which 23,070 MW are developable. It is one of China's biggest hydropower resource "motherlodes." Its cascade power station characteristics are small inundation losses and superior kinetic energy indices. The river segment between Shigu on the Li Jiang in Yunnan and Yibin in Sichuan is the

key development segment of the Jinsha Jiang. Plans call for developing eight cascades with a total installed generating capacity of 44,560 MW. The investigation group felt that two cascade power stations near Yibin in the lower reaches of the Jinsha Jiang, the Xiluodu and Xiangjiaba power stations, have superior development conditions and should be the research focus for near term and early development.

Xiluodu Hydropower Station will have an initial dam height of 275 meters, a total reservoir capacity of 12.1 billion cubic meters, an installed generating capacity of 10,080 MW, guaranteed power output of 3,460 MW, and yearly power output of 53.1 billion kWh. Its kinetic energy indicators are good and it is an especially large project. The large total reservoir capacity of this power station will give it good regulation capabilities and it can intercept some silt to create favorable conditions for developing the Three Gorges project. Preliminary prospecting at the Xiluodu dam site indicates that the topographic and geological conditions will permit construction of a high dam. The reservoir inundation losses are small, with unit electric power inundation indices far lower than those for power stations already built and now under construction in China. There is already a highway which runs to the Xiluodu dam site and communications are relatively convenient. If preparatory work can be pushed ahead, it is a good power source site for developing in the short term. Xiangjiaba Hydropower Station will have an initial dam height of 195 meters, a total reservoir capacity of 4.8 billion cubic meters, an installed generating capacity of 5,000 MW, guaranteed output of 1,690 MW, and yearly power output of 28.2 billion kWh. This power station is located in Sichuan's power use center and it will have comprehensive benefits from power generation, irrigation, water-borne transport, and so on. The dam site is located in an area with convenient water and land communications and a highway passes by it on the right bank. It is only 7 kilometers from Anbian station on the Inner Mongolia-Kunming Railroad and the waterway can handle 500-ton motor driven vessels. The problem with this project is that geological conditions at the dam site are complex, so further exploration and analysis are now under way. It is expected that a feasibility report can be submitted during the third quarter of 1989.

IV. Integrate Large, Medium, and Small Scales, Try To Complete Several Medium Hydropower Stations Before 2000 To Compensate for a Shortage of Installed Generating Capacity in Sichuan Now and During the Ninth 5-Year Plan

Since the Seventh 5-Year Plan began, development in the electric power industry in Sichuan Province has improved and the current scale of hydropower and thermal power stations now under construction in Sichuan is about 8,000 MW. Projections are that several key power stations may begin operating in succession between 1989 and 1992, and they can provide definite compensation for the electric power shortage. Because of the situation of rapid socioeconomic development in Sichuan, however, new power shortages will continue to

appear. This is particularly true prior to startup of Ertan Power Station, meaning prior to 1997, when basically no large power plants will begin operating. Since large-scale hydropower stations usually take a rather long time to build, with about 10 years being required from the time construction begins until they start operating, most projects included in the Eighth 5-Year Plan will only produce results after the year 2000. Expanding the installed generating capacity at thermal power plants will make it hard to solve both coal and transport problems. Thus, Sichuan can only rely on building several medium-scale hydropower stations which involve limited investments and short construction schedules and produce quick results and on a few large-scale hydropower stations with good development conditions and short construction schedules to compensate for the even more serious load shortages which will appear from 1993 to 1997.

Sichuan Province has 14,900 MW in developable medium-scale hydropower resources, equal to 22 percent of China's developable medium-scale hydropower resources. Sichuan has now completed 785 MW in medium-scale hydropower installed generating capacity. Added to the 240 MW now under construction and not yet operating, this is just 7.7 percent of the developable amount, so there is great potential. Looking at the regional distribution situation for medium-scale hydropower in Sichuan Province, the hilly area in the basin has about 1,600 MW, the mountainous region around the basin has about 5,000 MW, the plateau region of northwest Sichuan has 4,000 MW, and the mountainous region of southwest Sichuan has about 2,600 MW. For the distribution of river basins, the more concentrated ones are the trunk and tributaries of Qingyi Jiang, the middle reaches of Jialing Jiang, the trunk and tributaries of Fu Jiang, the trunk and tributaries of the middle reaches of Min Jiang, the trunk and tributaries of Qu He, Long He, Nanya He, Mabian He, and others. The investigation group focused this time on inspecting several medium-scale hydropower stations already built or to be developed on Qingyi Jiang and its tributary Baoxing He, the upper reaches of Min Jiang, the middle reaches of Jialing Jiang, Anning He, Nanya He, Wasi He, Mabian He, and other basins. These include many power stations with abundant flow, large natural heads, superior kinetic energy indices, small inundation losses, and good economic benefits which will facilitate the transmission of power into the grid. They have a definite foundation of preparatory work, urgent local demands to develop power, and other advantages. For example, Daqiao Power Station on Anning He, the cascade power stations on Wasi Gou, a tributary of Dadu He, Yuyu Power Station on the trunk of Qingyi Jiang, Tongtouchang Power Station on the tributary Baoxing He, Mahui, Qingju, and Dongxiguan Power Stations in the middle reaches of Jialing Jiang, Shaba, Tapingyi, and Zipingpu power stations on the trunk of the upper reaches of Min Jiang, and others can be selected for development in the short term. If we can strive to place 1,000 MW in medium-scale hydropower into operation

before 1995 and can achieve the plan to place an additional 800 to 900 MW into operation during the Ninth 5-Year Plan, be achieved, this could compensate for Sichuan Province's shortage of installed generating capacity during the Ninth 5-Year Plan.

Accelerating medium-scale hydropower construction in Sichuan first of all requires solving capital problems. The ways to do this are: 1) Make medium-scale hydropower development the focus of near-term electric power development in Sichuan Province and set aside part of the capital raised from electric power in Sichuan each year for use as a local medium-scale hydropower development fund. 2) Rely on prefectures and counties where power stations are located to raise part of the capital. 3) Try to have relevant departments and companies of central authorities provide some investments or low interest loans. 4) The compensated trade method also can be adopted to attract some foreign capital. Second, in the area of policies, specific preference should be provided to local medium-scale hydropower like "self-construction, self-management, self-utilization," "using power to develop power," and "low rates of taxation" or "tax reductions and exemptions" during the period of loan repayment, and so on. Third, we should accelerate the pace of preparatory work now, especially for projects which must begin in the short term, and implement expenditures if we are to effectively promote medium-scale hydropower development.

The solution to Sichuan Province's power shortage is a major effort to develop hydropower. We should begin now to push forward with building several medium-scale hydropower projects and give long-term consideration to the need to avoid wasting time in selecting several superior large-scale hydropower stations for construction. Only in this way can we speed up the solution to Sichuan's power shortage while at the same time using this as a tap to carry along sustained and stable development of industrial and agricultural production throughout Sichuan and invigorate Sichuan's economy. This was the common understanding of the "Three Rivers" investigation group.

Vital Role of the Three Gorges Project in Harnessing the Chang Jiang

906B0014A Beijing SHUILI FADIAN [WATER POWER] in Chinese No 9, 12 Sep 89 pp 7-12, 19

[Article by Hong Qingyu [3163 1987 0151] of the Chang Jiang Basin Planning Office: "Vital Role and Effect of the Three Gorges Project in Harnessing the Chang Jiang"]

[Text] The Chang Jiang is over 6,300 kilometers long and is the third longest river in the world, next only to the Nile and the Amazon. The total drop is more than 5,400 meters. It drains about 1,800,000 km², approximately one-fifth of the total area in China. Rainfall is

abundant in the Chang Jiang basin, averaging approximately 1,100 mm per year. On the average, approximately 1,000,000,000,000 m³ of water runs into the ocean. This is next only to the Amazon and the Congo. It is also in third place in the world. This is 20 times the amount of water to enter the ocean from the Huang He and represents approximately 30 percent of the surface runoff in China. The entire region has a reserve of 268 million kW of water power, of which approximately 200 million kW can be developed. This is 53 percent of the water power that can be developed in China. There are 363 million mu of farmland in the basin, approximately one-fourth of the available farmland in China. There are 358 million people in the region, approximately one-third of the population of China. It produces approximately 40 percent of the food, one-third of the cotton, 40 percent of the industrial productivity, and 70-80 percent of the river transportation in China. Based on these statistics, the significance of harnessing and developing the Chang Jiang to the economic growth of China is obvious.

In order to harness and develop the Chang Jiang, the Party Central decided to begin planning the development of the region in 1955 in order to formulate a strategy. Through a series of studies, it was demonstrated that the Three Gorges project plays a vital role and is a key engineering project in harnessing the Chang Jiang. In the 1983-1988 supplemental key issue reports on the planning of the Chang Jiang basin and the repeated feasibility demonstration of the Three Gorges project in the past 2 to 3 years, we have reached the same conclusions. The Three Gorges project will have a great effect on flood control in the middle and lower reaches of the Chang Jiang, particularly the Jing Jiang area. It can provide huge amounts of electric power to central and eastern China, alleviating the critical energy shortage situation in the region. It also can improve navigation on the Chang Jiang, especially below Chongqing. The effects of the Three Gorges project on flood control, power generation, and navigation are briefly described below.

I. The Three Gorges Project Is an Irreplaceable, Vital Component in the Flood Control System for the Middle and Lower Reaches of the Chang Jiang

1. The Focal Point of Flood Control Is the Plain in the Middle and Lower Reaches of the Chang Jiang

Flooding is a widely scattered problem along the Chang Jiang. The valleys and basins in the mountains where the main and secondary streams originate and the flat land, lake shores and beaches in the middle and lower reaches frequently suffer from flooding of various degree. Areas near the mouth of the river along the coast are also threatened by storms and tides. However, flooding is most serious in the plain in the middle and lower reaches. The total area of the plain is approximately 126,000 km², which is 80 percent of the flat land along the Chang Jiang. This area is densely populated and has a highly developed economy, including several major

commodity trade centers and industrial cities. It is one of the finest areas in China. However, the elevation of the area is generally below flood level. Dikes are used as the primary means of flood control. The level of protection is poor. Every disaster results in heavy losses. This is especially serious in the Jingjiang region (the mainstream section of the Chang Jiang between Yichong and Chenglingji mainstream is also known as the Jing Jiang). To the north is the Jianghan Plain and to its south is the Dongting Hu area. The total flood threatened area is approximately 40,000 km². Once the floodwater leaves the Three Gorges, this area is immediately in its path. The flood not only results in huge financial losses but also a great deal of casualty. Historically, this was an area of lakes, such as the ancient Yunmeng Lake. The floodwater from rivers in Sichuan used to hang around these lakes. However, because of natural evolution and human activity, the Yunmeng Lake on the north bank has become the vast Jianghan Plain and the Dongting Hu on the south bank has shrunk from 6,000 km² in early 19th century to 2,700 km² now. As a matter of fact, it has become the Dongting Plain which is created by a network of protective dikes and embankments. Based on the current situation, if a flood similar in magnitude to the one that occurred in 1860 or 1870 hits the Jingjiang area, it would be very difficult to avoid a destructive disaster killing thousands of people. This is the largest potential danger in flood control along the Chang Jiang. Therefore, the plain in the middle and lower reaches of the Chang Jiang is the focal point of flood control along the entire river and protecting the Jingjiang area from destructive flooding is an urgent task in flood control in the middle and lower reaches of the Chang Jiang.

Based on historic documents and investigative research, there have been over 200 major flooding incidents in the middle and lower reaches of the Chang Jiang over a period of 2,000 years, from the Han Dynasty to late Qing Dynasty. On an average, it happens every 10 years. Two major flooding incidents took place in 1860 and 1870. The peak flow at Zhicheng was approximately 110,000 m³/s. The plain area surrounding the lakes was totally under water and the damage was severe. In the 20th century, major flooding occurred in 1931, 1935, 1949, and 1954. The floods of 1931 and 1935 put 50,900,000 and 22,640,000 mu of land under water and killed 145,500 and 142,000 people, respectively. In 1931, Hankuo was submerged for 3 months. Although flooding was not particularly serious in 1949, however, because the region was just liberated and dikes were not properly maintained for years, it was still a serious disaster. Over 27,000,000 mu of land was under water and the Jingjiang Dike was almost destroyed. The flood of the century happened in 1954. Despite the use of the Jingjiang flood diversion project three times and creating numerous openings to protect the Jingjiang Dike and the city of Wuhan, the situation was still very serious. A total of 47,550,000 mu of land was flooded (22,000,000 mu of land was submerged prior to flood diversion) and over 30,000 people were killed. The Beijing-Guangzhou railroad could not operate regularly for 100 days.

2. Status of Flood Control in the Middle and Lower Reaches of the Chang Jiang

Because of the severity of the situation, the Chinese Communist Party and the government began a large-scale flood control project immediately after China was liberated. First, dikes were strengthened and flood storage areas were constructed. A total of 3 billion cubic meters of earth and stone were completed. In order to alleviate the serious threat of flooding to the Jingjiang area, the government mobilized 300,000 military and civilian personnel for 75 days to construct the Jingjiang flood diversion project. This was done in 1952 when our financial, material and technical resources were still very weak. It became very effective in the flood of 1954. After over 30 years of construction, compared to the situation immediately after the liberation of China, flood control has been improved by different degree in areas along the middle and lower reaches of the Chang Jiang. This plays an important role in protecting the economic growth in the region. Nevertheless, the basic problem, the mismatch of the flood discharge capacity of the river channel and the flood flow, has not been solved. The safe discharge rates at various sections are: 60,000 m³/s at Jingjiang (including diversion at Songzikuo and Taipingkuo), under 60,000 m³/s near Chenglingji, close to 70,000 m³/s in the vicinity of Wuhan, and approximately 80,000 m³/s below Hukuo. However, in the past 100 plus years since records began to be kept in 1877, the peak flood at Yichang exceeded 60,000 m³/s 23 times. In the period of over 800 years since 1153, eight times flood exceeded 80,000 m³/s and five times it went over 90,000 m³/s. The maximum flow of the Chang Jiang at Yichang and those of the four rivers (i.e., Xiang, Zi, Yuan and Li) reached over 100,000 m³/s in major flood years. The fact that flood flow far exceeds the safe discharge rate of the river is the cause of flooding in the middle and lower reaches of the Chang Jiang. On top of that, because of silt-up of lakes, population explosion, and economic growth, flooding will cause much greater losses and bring far-reaching effect on the economy. Therefore, the flood control situation in the middle and lower reaches of the Chang Jiang, especially in the Jingjiang region, is still very grim.

This flood control problem has been studied, demonstrated and reviewed repeatedly for a long time. Because of its extraordinarily high peak, the policy is to use both storage and discharge means, while focusing primarily on flood discharge. The principle is to benefit both the river and the lakes. Dikes should be raised higher and strengthened, flood storage areas should be constructed on the plain, and reservoirs should be built along the mainstream and branches of the river according to the Three Gorges project to solve the flood control problem in the region.

In order to push for the construction of flood control projects to improve the situation, flood control discussion meetings were held in 1972 and 1980. The focus was placed on the study and layout of near term flood control projects prior to the completion of the Three Gorges

project. It was concluded that we should concentrate our effort on raising and fortifying dikes and building flood diversion regions in order to reach the point that we can protect key areas against a flood of the same magnitude as the flood of 1954. The provinces along the river are proceeding with the plan and objectives set in the 1980 meeting. Upon completion of the 1980 plan, there are still the following major problems. 1) The flood prevention standard is still low. Although key dikes and cities can be protected from any flood similar in magnitude to the flood of 1954, however, dikes can only protect us from major floods that occur every 10-20 years. Beyond this scale, we have to use flood diversion areas and pay a big price. These flood diversion areas in the middle and lower reaches of the Chang Jiang have been cultivated. Flooding will result in huge losses. This is a measure of choosing a lesser evil. Based on an analysis, if we have another flood of the same magnitude as that of the flood of 1954, ideally it is necessary to divert 50 billion m³ of floodwater and submerge 10 million mu of land. Based on the current condition of the flood diversion area and 1986 cost of goods, the direct financial loss is approximately 20 billion yuan. After the 1980 plan is fully implemented, only key areas, not the entire region, are protected from any flood up to the magnitude of the flood of 1954. Moreover, the price to pay for protecting these key areas is also enormous. To use dikes to protect an area from flooding is a 10-20 year measure from the standpoint of flood control. 2) The flood of 1954 is merely the flood of a decade for the Jingjiang region. Dikes can be relied upon to protect the Jingjiang area from major floodwater that occurs every 10 years or so. With flood diversion, dikes can protect the area from major flood for approximately 40 years. This level of protection is extremely out of proportion compared to the importance of the area. There are no other reliable measures to prevent the disaster of a super flood. If the floods of 1860 or 1870 happen today, the maximum safe flow at Zhicheng is 80,000 m³/s after taking flood diversion measures. This means that an excess of 30,000 m³/s of floodwater cannot be safely discharged. This will lead to the collapse of major dikes in either banks. If it collapses on the south bank, floodwaters run into the Dongting Hu region. The current network of embankments cannot stop it. If the floodwater goes north, the Jianghan Plain will be flooded and the city of Wuhan will be threatened. The north bank is over 10 meters below flood level. The terrain of the south bank runs lower toward south. No matter whether the floodwater goes north or south, it will cause tremendous destruction of life and property and serious social and economic consequences. Therefore, even after the 1980 plan is fully implemented, the flood control picture is still very grim. In particular, the danger of having a destructive disaster to occur in the Jingjiang area still exists.

3. Construction of the Three Gorges Project Can Significantly Raise the Flood Control Standard in the Middle and Lower Reaches of the Chang Jiang

In order to solve the flood control problem, various schemes with and without the construction of the Three

Gorges project have been studied over the years. The conclusion is that the flood control standard downstream cannot be substantially improved without building the Three Gorges project. There are no other reliable measures to prevent disasters from happening in the Jingjiang area. The same conclusion was reached in the recent deliberation. Thus, in order to solve the flood prevention problem and eliminate the danger of destruction, reservoirs will have to be built both up and downstream centered around the Three Gorges project.

The Three Gorges project is located approximately 40 kilometers upstream from Yichang, immediately close to the Jingjiang section of the Chang Jiang where flood control is most rigorous. It controls more than 95 percent of the floodwater from above the Jingjiang section and two-thirds of the floodwater above Hankuo. Using the Three Gorges project to block and store the floodwater is the most effective measure to alleviate the threat of flooding and prevent devastating disasters in the Jingjiang region. After years of study and repeated deliberation, the Three Gorges project is considered a key component of the flood control system for the middle and lower reaches of the Chang Jiang. It is irreplaceable for the safe passage of floodwater in the Jingjiang section.

In this renewed deliberation, a 175 m normal water storage level plan was recommended for the Three Gorges project. It has a flood control capacity of 22.15 billion m³. A team of experts demonstrated that the project has the following flood control functions: 1) The flood control standard in the Jingjiang section can be raised from 10 to 100 years. This means that unless we have a major flood of a century, normal floodwater can be regulated by reservoirs and be safely discharged without using flood diversion areas. 2) If we are hit by a major flood in 100 to 1,000 years, or a super flood similar in magnitude as that that occurred in 1870, after being regulated and stored in reservoirs, the maximum flow at Zhicheng will not exceed 71,700-77,000 m³/s. In conjunction with other flood diversion measures, devastating disasters can be avoided in the Jingjiang area. 3) Since floodwater is effectively controlled upstream, the threat to Wuhan is reduced. Thus, the reliability and flexibility of flood prevention facilities in Wuhan are improved. 4) The amount of sand entering the Dongting Hu is reduced; not only reducing the threat of floodwater from the Chang Jiang to the Dongting Hu area but also slowing down the silting up of the lake and lengthening its useful life. In addition, it also provides conditions for the construction of locks in four places such as Songzi and for harnessing the Dongting Hu. 5) The project reduces the probability of using flood diversion areas down the river and lowers the amount of floodwater each area has to share. Consequently, the loss due to flood diversion is reduced. Over the years, on an average 300,000-400,000 fewer mu of land will have to be submerged every year. Including the damage to towns and cities flooded, it can reduce flood damage by 970 million yuan (1986 level) every year. If the flood of 1870

happens again, it will result in a reduction of direct financial loss of 35 billion yuan.

4. Several Opinions on Flood Control in Middle and Lower Reaches of the Chang Jiang

(1) Solving the flood control problem by depending on dikes and storage of water in lakes and low land alone. Construction of dikes and flood control projects is an important measure to contain floodwater in a river. When it is not possible to build a reservoir to regulate floodwater, it may be the only way. However, there are many examples in the world that reservoirs are used as key components in flood control. For example, the Sanmenxia reservoir on the Huang He, the Guanting reservoir on the Yongding He, and the Danjiangkou reservoir on the Han Jiang are very effective in flood control. Whether reservoirs need to be built at the Three Gorges requires research and planning, instead of based on simple analogy. Based on years of research, it is not enough to rely on dikes alone to prevent flooding in the middle and lower reaches of the Chang Jiang. Furthermore, it is very costly to use flood diversion. It essentially sacrifices one area to save another in order to reduce the scope of the disaster. Moreover, if a major flood that happens every 40 years hits the Jingjiang area, especially in the same magnitude of the flood of 1860 or 1870, it would be very difficult to avoid major disasters from a major dike or dam burst, even with flood diversion.

In the past century, although dikes have been improved significantly along the Chang Jiang, other conditions, such as the south bank terrain, embankments in the flood areas, flood discharge capacity of the Jingjiang section, have also changed a great deal. Today, the Jingjiang section can only safely discharge 60,000-68,000 m³/s of water coming from Zhicheng. With the Jingjiang flood diversion plan and other temporary openings, it can only handle approximately 800,000 m³/s. If the flood of 1870 occurs again, the maximum flow at Zhicheng is expected to reach 110,000 m³/s. Even with flow diversion, major dikes on the south bank will burst. However, the amount of overflow is limited by the terrain and embankments. There is a possibility that water level may exceed the assurance level for the Jingjiang dike, leading to the burst of this major dike on the north bank. In addition, in 1870 the main deep channel of the Chang Jiang was located to the south of Shangbailizhou which made Songzikuo the first spot to burst. Today, the main deep channel has shifted to the north of Shangbailizhou. Based on the current terrain and river situation, the dike at the tip of Shangbailizhou may burst first. The floodwater may return to the Chang Jiang from Yangjianao and then rush toward the river bend in Shashi, threatening the Yanka section of the Jingjiang dike. Hence, there is a possibility for the north side to burst first. However, no matter whether the north or south side bursts first, the disaster is devastating. Based on years of research and repeated deliberation, we always reach the same conclusion that flood control standard along the Chang Jiang cannot possibly be

improved without building the Three Gorges project. Hence, it is impossible to prevent the Jingjiang area from devastating disasters due to severe flooding. The Three Gorges project is an integral part of the flood control system in the middle and lower reaches of the Chang Jiang and must be constructed.

(2) Can the flood control problem down the Chang Jiang be solved by building reservoirs on its tributaries upstream, instead of going ahead with the Three Gorges project? This type of scheme has been studied in great detail by the Chang Jiang Planning Office for years. A group of experts also studied it this time. The conclusion is that although reservoirs on tributaries may control local floodwater and have a significant effect on flood prevention along the river, however, because of unpredictable rainfall pattern sometimes they are not useful in flood control down river. The peak of the flood rushing down the river cannot be effectively controlled by reservoirs scattered along the tributaries upstream. In addition, between the area to be controlled by tributary reservoirs and Yichang, there is another 300,000 km² of torrential rain area that the reservoirs cannot control. The floodwater from this area alone can threaten the safety of the Jingjiang area. Therefore, building tributary reservoirs alone without construction of the Three Gorges project cannot meet the needs of flood control down river.

(3) Some comrades believe that floodwater primarily comes from four sources, i.e., rivers in Sichuan, four rivers in Hunan, the Han Jiang and the Gan Jiang, and the Three Gorges project can only control a portion of the floodwater from the rivers in Sichuan. Thus, there is the issue that it only has limited effect on flood control along the Chang Jiang. In reality, although floodwater comes from several sources, most of it still comes from upstream, i.e., the so-called Chuan Jiang flood. This can be demonstrated statistically. The average amount of floodwater from Yichang in July and August makes up 80.3 percent of the floodwater to reach Chenglingji and 72.0 percent of that to reach Hankou. In years with major flooding, such as 1931, 1935, 1949 and 1954, 61.4-79.5 percent of the floodwater to reach Chenglingji and 55.1-76.2 percent of that to reach Hankou came from Yichang. As far as the Jingjiang section is concerned, more than 95 percent of the floodwater comes from the Chuan Jiang. Therefore, regardless of the type of flood, controlling the Three Gorges can effectively prevent flooding in the middle and lower reaches of the Chang Jiang, especially for the Jing Jiang area. Results from flood control computation based on several typical flood patterns also verified this point. Of course, the function of the Three Gorges project varies for different types of flood. Nevertheless, we cannot jump to a conclusion that the Three Gorges project has little flood control effect based on a specific type of flood. The Three Gorges reservoir will be regulated to compensate the situation downstream. It offsets the peaks of the floodwater in some tributaries downstream in order to make flood control there easier. However, we cannot

possibly ask the Three Gorges reservoir to solve the flood control problems associated with all tributaries. The Three Gorges project is a vital part of the flood control system along the Chang Jiang. However, this does not imply that it is capable of handling all flood control functions. It certainly does not imply that the Three Gorges reservoir alone can solve all the flood control problems down river.

(4) Flood control effect with respect to Wuhan. Upon completion of the Three Gorges project, the highest flood control water level is still set at 29.73 m. This is determined based on the overall principle of using both storage and discharge for flood control while focusing on discharge. Because of the high floodwater peak in the Chang Jiang, the safe discharge rate of the river should be fully utilized before the magnitude of flood diversion project and reservoir floodwater holding capacity are considered. Currently, the safe discharge rate in the Wuhan area is 70,000 m³/s at a water level of 29.73 m. This is the highest water level actually reached in the flood of 1954 and is also the assurance level of all the flood control facilities in the city. If this level is lowered, the floodwater discharge capability in this section also drops. Correspondingly, the amount of excess floodwater to be handled upstream is increased. Thus, it requires the Three Gorges reservoir to have a larger floodwater retention capacity, or increase the amount of floodwater entering flood diversion zones. These are unacceptable. In reality, after being regulated by the Three Gorges reservoir, the amount of discharged floodwater will decrease. As a result, less floodwater will enter the Wuhan area. This makes less probable to reach the maximum water level. Thus, there is more flexibility in flood control which effectively raises the flood control standard. In addition, the safety of the Jingjiang dike is closely related to flood prevention in Wuhan. Once the Jingjiang dike bursts, the safety of Wuhan cannot be ensured. Therefore, the Three Gorges reservoir ensures the safety of the Jingjiang dike, and also indirectly protects Wuhan from flooding. Hence, it is obvious that the Three Gorges project benefits the flood control in Wuhan.

(5) Is the backwater and silt-up in the Three Gorges reservoir going to aggravate flooding in the Sichuan Basin? Upon completion of the Three Gorges reservoir, water level will be raised upstream. The amplitude of elevation is the highest at the site of the dam and gradually decreases as it moves farther upstream. Based on the plan which calls for a normal water level of 175 m, water level will be raised by 110 m. At the tail end of the reservoir (or the end of backwater), it is close to the natural floodwater level, i.e., the elevation is close to 0. Farther upstream, it is no longer affected by the reservoir. In the 175 m plan, residents will be relocated based on the standard of major flooding occurring every 20 years. The backwater ends at Mudongzhen in Baxian, downstream from Chongqing. If the flood of the next 20 years hits after the reservoir is constructed, residents from Mudongzhen on down will not be flooded since

they have been relocated according to this flood line. Upstream from Mudongzhen is no longer affected by the reservoir. Therefore, it is only susceptible to natural flooding. Based on our survey, some cities, towns and populated spots along the river are flooded every 5 years. In the event of a major flood that happens every 20 years, 114,200 people will be affected in the reservoir area. After the reservoir is constructed, they will be spared. In case of a major flood larger than that happens every 20 years, because the water level in front of the dam is higher than the high-water mark that happens every 20 years, the backwater will also extend upward. Based on our estimates, within the backwater area that we see every 100 years, 237,000 people would be affected if the reservoir is not constructed and only 1,100 people would be affected after it is finished. The backwater affects a limited area. Beyond this area, the scope of flooding is determined by natural causes alone and essentially unaffected by the construction of the reservoir. Within the backwater zone (i.e., inside the reservoir area) flooding is diminished instead of aggravated. The Three Gorges is located on the east side of the Sichuan Basin. The backwater affected elevation is far lower than the elevation of the Sichuan Basin. (The elevation at the center of the basin near Chengdu is around 500-700 m.) It is obvious that this will not aggravate flooding in the Sichuan Basin.

As for the effect of silting-up on the backwater at the tail of the reservoir, after putting the reservoir in operation for several decades, silting will raise the backwater level. Based on an estimate, under the condition that no other reservoir will be built upstream to block sand and regulate floodwater, after 20 years of operation, the water level at Chaotianmen in Chongqing will be raised by 1.06 and 1.9 mm when we are hit by a major flood that happens very 20 and 100 years, respectively. This additional loss due to elevation of backwater needs to be resolved. Measures to be taken to address this problem were included in the feasibility report. In addition, with treatment of soil erosion and construction of reservoirs upstream, the effect of silt buildup will be significantly reduced. Afterward, it would no longer aggravate the flooding problem.

Submerging land and relocating people in the reservoir area would definitely cause some losses. However, there are always gains and losses in a construction project. In order to gain some benefits, we have to pay the cost. From an overall perspective, the benefits of the Three Gorges project in flood control, power generation, and navigation far outweigh the losses to flooding. The flooded area will be properly compensated and the people will be relocated according to a development plan. This not only takes care of the people to be relocated but also creates some conditions for future economic growth in the reservoir region.

II. The Three Gorges Project Can Provide Cheap, Clean Electric Power for Central and Eastern China

Central and eastern China are economically developed regions. The industrial and agricultural products from these regions play a vital role in China's economy. However, the shortage of energy and power has become a limiting factor preventing local economy from further growth. The shortage of electricity is grim. Both areas have insufficient coal supplies and require shipment from outside areas. The pressure on transportation is also very high. Therefore, developing hydropower to supply electric power to eastern and central China will effectively lower the pressure on coal supply and transportation and reduce environmental pollution caused by burning coal. There is not a great deal of water conservation resources in eastern China and most of them have been developed. Water power resources are abundant in central China. Undeveloped hydro-power resources are primarily concentrated in the Three Gorges section of the Chang Jiang and the upper reaches of its tributaries such as the Yuan Shui and Qing Jiang. Approximately 70 percent of the resources is concentrated in the Three Gorges areas which makes its development favorable. Sufficient early phase work has been done and geographically it is closer to eastern and central China where the power load is high. Therefore, it is an ideal spot to develop electric power in the near term.

Based on years of research, the Three Gorges project has three major advantages: high capacity, large power generation capacity, and proximity to major load areas. In this recent deliberation, it was compared with several other plans. The conclusion is that the Three Gorges project is the best plan to provide electric power to eastern and central China. For the plan which calls for a normal water storage level of 175 meters, the total generating capacity to be installed is 17,680,000 kW and the annual power output is 84,000,000,000 kWh. This can effectively reduce the shortage of electricity in eastern and central China.

The Three Gorges project will require a total of 18 years to complete. However, production can begin in the 12th year after preparation for construction begins. It takes 3 years to prepare for construction and does not cost a great deal of money. In addition, after the first set of generators is put in operation, a set of four 680,000 kW generators can be installed and put in operation every year for 6 years. This means 2,720,000 kW can be added every year, which is equivalent to adding a Gezhouba Power Station every year. Therefore, although the total construction period is long, the actual amount of construction time required to be in operation is more or less the same as that for a large hydropower plant or a thermal power plant with its associated coal mines. Further, due to its superior natural conditions and overall benefit, economic indicators for the Three Gorges project are also very good. Based on the comprehensive economic evaluation given in this round of deliberation, intrinsic profit ratio of the Three Gorges project could reach 14.54 percent according to a

dynamic economic analysis. This is higher than the 10 percent guideline set by the State Planning Commission. In the feasibility demonstration of using the Three Gorges project to supply electricity to central and eastern China, the team of experts studied several alternate plans. It was concluded that the Three Gorges project is the optimal plan with the lowest construction cost. Furthermore, no matter from the standpoint of optimized power distribution planning or conventional regional electric power regulation, the Three Gorges power plant will eventually replace thermal power plants. This is because the Three Gorges project and other hydropower plants have their own areas to serve, thus they cannot replace each other. Instead, they will replace thermal power plants to save coal. The Three Gorges project and other hydropower projects do not mutually exclude or replace each other. Rather, proper arrangements should be made based on the geographic location, customers served, regional economic growth demand and depth of preparatory work.

III. The Three Gorges Project Can Improve Navigation on the Chang Jiang, Promote Economic Exchange Between Southwestern China and Central and Eastern China, and Accelerate Economic Growth in the Southwest

The Chang Jiang is a major artery for east-west transportation. It connects three major regions, i.e., southwest, central, and eastern China. In conjunction with its tributaries and canals, it is the largest inland water transportation network. Chongqing up the river, Wuhan in the middle and Nanjing down the river are the three major pivotal cities. Shanghai, a city on the Chang Jiang, is the largest city along the coast and it is China's economic center. As the economy grows further, navigation on the Chang Jiang will be even more important.

Since the founding of the People's Republic of China, due to construction and improvements over past years, a great deal of progress has been made in areas such as navigation channels, ports and ships. Its shipping capacity is also increasing constantly. In 1985 the total amount of goods transported on the Chang Jiang reached 275 million tons. The amount of goods transported on the Chang Jiang in Sichuan has grown rapidly in recent years. From Gezhouba downstream, it had reached 5.04 million tons in 1987. Based on the projection provided by the team of experts, it is reasonable to consider that the shipping capacity down the river can reach 1.55 million tons in 2000 and 50 million tons in 2030.

Nevertheless, as it stands, navigation on the Chang Jiang cannot possibly meet the needs in economic development. The navigation channel in Sichuan from Chongqing to Yichang can accommodate ships up to 3,000 tons. From Yichang to Linxiang, ships up to 6,000-8,000 tons can pass. Ships over 10,000 tons can pass from Linxiang downward. To fundamentally improve the navigation situation and raise its passing

capacity, the natural condition of the shipping channel from Chongqing downward must be altered. In addition, the flow in the shipping channel has to be increased during dry season to raise the depth of the river to facilitate navigation.

Chongqing is a major distribution center in the southwest. From Chongqing to Yichang, the river runs through over 600 kilometers of hills and gorges with a drop of approximately 120 m. The current is swift and dangerous shoals are everywhere. Along the way, there are 139 shoals and 46 one-way sections. It is poor for navigation. The towing capability per horsepower is only one-tenth of that down the river and the transportation cost is approximately three times higher than that downstream. Upon completion of the Gezhouba reservoir, the 130 km of channel above Yichang was improved. However, the navigation channel in the Chang Jiang in Sichuan has not yet been fundamentally fixed.

The one-way capacity from Chongqing downward is approximately 10 million tons. Our study shows that it is possible to take certain measures to treat the problem in order to meet the demand due to economic growth. However, in order to have a one-way capacity of 4.3 million tons, it is going to cost 3.227 billion yuan with no reduction in transportation cost. Based on experience gathered here and abroad in improving navigation channels in mountain regions, the only way to effectively use this waterway, in addition to modernizing ports, building large ships, adopting advanced technology and strengthening scientific management, is to build dams and canals. Thus, a transportation network of land and water centered around the mainstream of the Chang Jiang is formed to serve the entire basin and the entire economy.

According to the 175 m plan, backwater can reach the port of Chongqing. The 600-kilometer channel from Chongqing to Yichang can be significantly improved. Approximately 6 months out of a year 10,000-ton ships can sail directly to Jiulongpo harbor in Chongqing. Because dangerous shoals are submerged, water depth is increased, grades are reduced, and water flow is slowed down, shipping efficiency will be significantly raised. The cost can be lowered by 35-37 percent and safety is improved. Thus, navigation will be stimulated to grow further. In addition, due to reservoir regulation, the flow rate below Yichang in dry season can go up from $3,000 \text{ m}^3/\text{s}$ to $5,000 \text{ m}^3/\text{s}$ to increase the water depth in the middle reaches, especially along the Jing Jiang section, to facilitate navigation.

In summary, the construction of the Three Gorges project will benefit navigation. However, there are also several serious issues to be dealt with, such as the effect of silting in the channel and harbor, effect of channel alteration below Gezhouba on navigation, design optimization and reliability of navigation facilities associated with water locks across the dam, navigation between Gezhouba and the Three Gorges, navigation

during construction period, and upstream linkage. These issues have been studied in depth in the feasibility stage and the recent deliberation. Tests were conducted and preliminary results have been obtained and countermeasures have been proposed to satisfy the requirements in the feasibility stage. However, some problems still need to be investigated in depth in the design stage to ensure that the Three Gorges project can most effectively improve navigation in the area.

From the above, it is obvious that the Three Gorges project is a key project to harness the Chang Jiang. The overall benefit is tremendous. Not only it should be built but also it must be built as soon as possible to benefit the mankind.

Update on Lijiaxia Hydropower Station

*40100031A Beijing XINHUA in English
0856 GMT 20 Feb 90*

[Summary] Beijing, February 20 (XINHUA)—Construction of the Lijiaxia Hydropower Station, the biggest on the Yellow River, has gone well and the cofferdam will be completed after the coming flood season, ECONOMIC INFORMATION reported today. This is the third of the 15 hydro-electric power stations to be built on the Yellow River. Construction of the project started in April 1988. With a generating capacity of 2 million kilowatts, the station will generate 5.9 billion kWh of electricity a year. Work on a 1,146-meter diversion tunnel is well under way and a highway leading to the power station and other structures have been completed.

Baotou No 2 100 MW Unit Readied for Operation
906B0029A Hohhot NEIMENGGU RIBAO in Chinese
30 Oct 89 p 1

[Article by Zhu Fu [4376 4395]]

[Text] After the Fengzhen power plant No 1 200 MW unit began operation and joined the power grid, the No 2 100 MW unit of the Baotou No 2 thermal electric power plant will also begin operation on 15 November 1989.

Today, the boiler and the turbine of the 100 MW unit have been installed and are being tested. The boiler was fired up for the first time in September and operated for 20 hours. The generator, originally scheduled to arrive in May, was not delivered until September, which delayed the schedule. Today, workers of the Inner Mongolia No 1 Electric Power Construction Company are working around the clock to ensure the operation target date of 15 November 1989.

Work Proceeding Apace on Dagang Expansion Project

906B0029B Beijing JINGJI RIBAO in Chinese
15 Dec 89 p 1

[Article by Han Fa [3352 4099] and Jian Ping [1696 1627]]

[Excerpts] In recent days a cold front from eastern Inner Mongolia has been moving onto the plains of north China. The area near Bohai Bay not only had a rapid drop in temperature but also 6-7 grade wind. In this weather, the second phase expansion construction of the Dagang power plant forged ahead.

The second phase Dagang project is one of the priority energy projects in the Seventh 5-Year Plan. The total investment in this project is about 1.5 billion yuan, the plan calls for two new 320 MW units. Machinery will be imported from Italy. The main part of the construction engineering is contracted to Tianjin Electric Power Construction Company and the 18th and 16th bureaus of the Ministry of Railways. Since construction began in June 1988, the project has been plagued by a variety of problems, including shortage of funds due to material price rise, delays in completing the designs by two companies here and abroad, and delays in importing the mechanical equipment. [passage omitted] Today, 80 percent of the civil engineering work has been completed, equipment installation is back on schedule, and the acceptance rate has been 100 percent, and superiority rate exceeded 80 percent. The project is expected to be completed on schedule in 1990.

State Council Approves 49 Coal-Fired Power Projects

906B0029C Shanghai JIEFANG RIBAO in Chinese
9 Dec 89 p 1

[Article by reporter Zhao Mingliang [6392 2494 0081] and correspondent Wang Xianguang [3769 7359 0342]]

[Text] With the approval of the State Council, the State Planning Commission recently announced 49 large and medium preparatory projects in coal and electric power capital construction; among these projects, 29 involve coal and 20 electric power.

According to the National Energy Resource Investment Company, the investment in these coal and electric power projects is 45 percent of the total investment this year in national capital construction preparatory projects, showing that the policy favoring energy basic industry is being implemented.

It is reported that most of these preparatory projects will begin construction next year. After the completion of these projects, the annual coal output of China will increase by 49.24 million tons, the electric power generation capacity will increase by 10.5 million watts, and 500,000-kV power transmission lines in China will be increased by 330 kilometers. Also included are eight projects that utilize foreign capital and two energy conservation projects.

In order to prepare for the initial work on these projects and to ensure a starting date of 1990, the state has provided 700 million yuan for land acquisition, water, electricity, and road work.

Fengzhen Generation Unit Officially Operational

906B0029D Beijing RENMIN RIBAO in Chinese
8 Dec 89 p 2

[Article by Qu Zhenye [4234 2182 2814]]

[Text] A new electric power plant has been built below the ancient Great Wall by the Yinmahe River. The Fengzhen No 1 unit in Inner Mongolia, one of the priority projects in the Seventh 5-Year Plan, became officially operational yesterday. This 200 MW unit is the first electric generation unit designed and built by the Inner Mongolia Autonomous Region.

The Fengzhen plant is a key power plant that connects the power grids in western Inner Mongolia and in north China. Its completion will be significant for the goal of transmitting electric power from western China to the east.

Hong Kong Group Invests in Shantou Power Plant
906B0029E Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 2 Dec 89 p 3

[Article by reporter Weng Zuoxiang [5047 0155 4382] and correspondent Chen Enchuan [7115 1869 3123]]

[Text] Chairman of the board Li Jiacheng [2621 0857 6134] of the Changjiang Enterprise (Group), Ltd., signed a letter of intent with the Shantou Municipal Government and the Shantou International Electric Power Development Co., Ltd., to participate in the investment of a 100 MW thermal electric power plant.

Shantou, Guangdong, has been plagued with electric energy shortages that affected the economic development and the civilian life. In recent years Shantou has built some power generation units and alleviated the shortages somewhat, but the needs in economic development are not met yet.

The Shantou economic zone is one of the four economic zones in China. According to the letter of intent, the

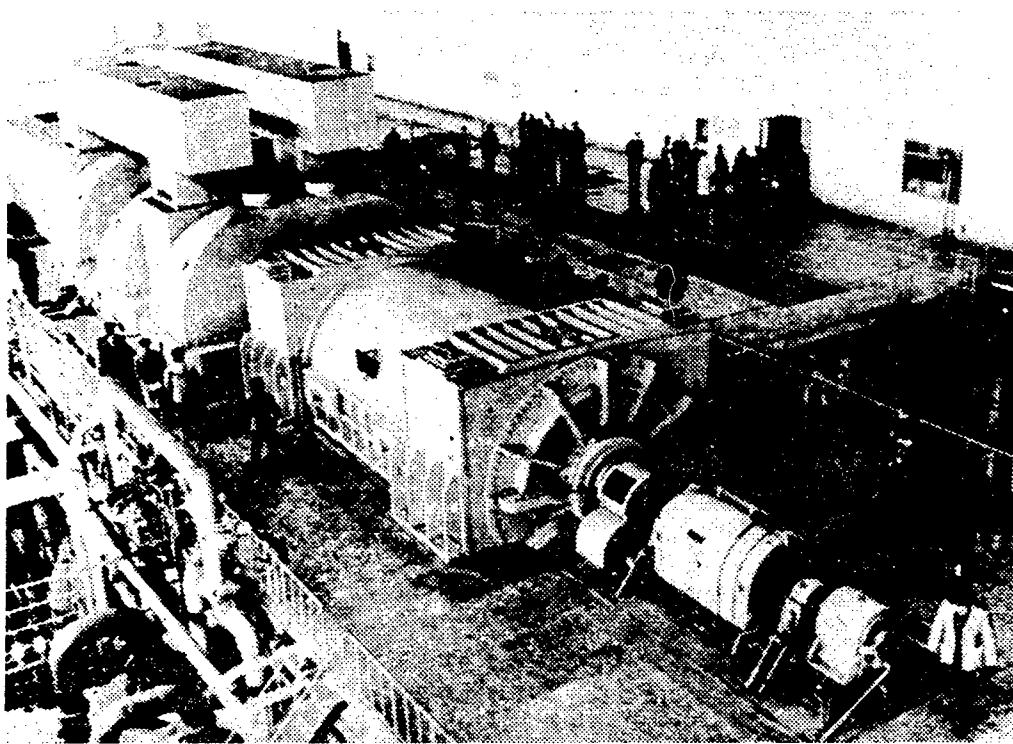
plant will produce 500 million kWh of electricity per year. The investment will be 60 million U.S. dollars and the construction will be contracted out to the Shantou International Electric Power Development Co. As to the needed investments, the Shantou University Foundation, Inc., a company formed overseas, will provide 10 million U.S. dollars, and the rest of the investment will be raised by this company overseas.

At the signing of the letter of intent, Mr Li said that the Shantou University Foundation, Inc., will invest \$10 million of capital, and all the interest and profits generated in future operations will be used to fund the development of the university and the medical school.

Guizhou's Qingzhen Plant Adds Two 200 MW Units to Grid

40130013A Shanghai JIEFANG RIBAO in Chinese 3 Jan 90 p 4

[Text] [Photograph and caption]



The third-stage expansion project of the Guizhou Qingzhen power plant, a major state construction item, recently put two 200 MW generators into operation. This will help ease the severe power shortage situation in Guizhou Province.

Coal Output Hits 1 Billion-Ton Mark

906B0031A *Guangzhou NANFANG RIBAO* in Chinese
28 Dec 89 p 3

[Text] China's coal production hit a new high this year. According to the Ministry of Energy, as of 27 December, China's output of raw coal exceeded the 1 billion-ton mark; thus accomplishing the target of the Seventh 5-Year Plan 1 year ahead of schedule.

It is said that raw coal output this year will reach 1.04 billion tons, 60 million tons more than last year's level at a growth rate of 6 percent. The output of unified distribution coal mines in China set three new records this year. Coal production in 1989 increased 20.50 million tons or 4.8 percent, which was the largest increase in the last decade. All-worker efficiency reached 1.14 tons and enjoyed the fastest increase in the last 10 years.

Big Yanzhou Mine Now Operational

906B0031B *Beijing RENMIN RIBAO OVERSEAS EDITION* in Chinese 25 Dec 89 p 1

[Article by Xie Jing [6200 2417], New China News Agency 24 Dec]

[Text] A ceremony was held this morning at the Shandong Yanzhou Mining Bureau to celebrate the start of operation of the Jining No 2 mine. The official operation of the extra large coal mine, designed to produce 4 million tons of raw coal per year, marks the onset of the Jidong coal mine development.

The Yanzhou mining zone is located in southwest Shandong and consists of two large coal fields. One is the Yanzhou mine, now completely developed, and the other is the coal mine in eastern Jining, which has been included in the national development plan. The Jining No 2 is the first pair of shafts in the Jidong coal field. The area of Jidong field is 350 square kilometers and the geological reserve is 2.44 billion tons. The coal species is a gas rich coal ideal for coking and power uses. The state has approved the field to construct four pairs of large and extra large coal mines. In addition to the newly finished Jining No 2, there is the Jining No 3 with an annual output of 5 million tons, and Xuechang and Daishan mines, each with an annual output of 1.5 million tons. The designed total output is 12 million tons and the field will take 15 years to complete.

Views on Building a Modern Coal Industry

906B0031C *Beijing KEJI RIBAO /SCIENCE AND TECHNOLOGY DAILY* in Chinese 19 Nov 89 p 4

[Article by Shang Haitao [1424 3189 3447], bureau chief of Luan Coal Mine in Shanxi]

[Text] In the 10-year reform and especially since 1985, we at Luan Mining Bureau have always kept in mind that "science and technology is the number one production force" and adhered to a technological approach. In 1986

we completed China's first modern coal mine and blazed the trail for the modernization of the coal industry.

In the past we used drilling, blasting, and manual loading in mining our coal. The production missions were accomplished by simply putting in more manpower. Beginning in 1980, we started developing integrated mechanized mining of coal. In 1985 we established a policy that stressed integrated mining technology, supplemented by mechanized transport and computers. We implemented the comprehensive technological improvement strategy and fundamentally changed the production technology in our bureau. Today, we have reached 100 percent integrated mechanized mining and 58 percent mechanized excavation, both are highest in the nation as compared to others in the industry.

Progress in production technology is not only a revolution in technology but also in ideology. It is a complex system engineering and takes a variety of progressive measures to convert science and technology into productivity.

First advanced technology and equipment must be studied carefully and perfected to suit our situation. In 1980 we imported our first integrated excavation equipment. In order to make it suit our particular production situation, we formed a task force of technical staff and disassembled the equipment. Based on our mining conditions, we modified 28 components and parameters and ensured success in the first run.

Next we must work on the continued engineering education of the technical staff and technical training of the workers. In order to implement the technical advance strategy, we established a complete continued engineering education and technical training system. Based on the principle of "learning what you do and supplement what you lack," we have held workshops on new knowledge and new discipline, and organized new technology seminars, foreign visits, university exchanges and lectures at the mining sites by invited experts. These practices have promoted knowledge renewal of the workers. The staff are evaluated rigorously in their on-the-job training and on-leave training. Cadre, staff and workers received monthly supplemental pay for buying books and references. In recent years the bureau sent 2,400 people each year to receive outside training. The training centers and mining schools of the bureau provided 10 to 15 days of training for workers on the first line. This training has improved the quality of the staff and workers and made them the main force in the technological improvement activity.

Third, we must improve our management and let scientific management replace the traditional management by experience. New technology and new equipment are built on rigorous scientific basis; only scientific management can bring out the efficiency. Our past problems in running the imported automated equipment have amply demonstrated the importance of scientific management. In the area of management we stressed three things.

First, establish a comprehensive scientific management system for the whole staff and the entire production process; second, strengthen the teams and improve the on-site management; third, make sure the new equipment is complete and compatible. For example, we developed the first model 650 conveyor belt system in China that was compatible with the integrated excavation equipment and improved the efficiency. Today, the nine mining teams in our bureau are each producing more than 1 million tons of coal per year and two of the eight excavation teams achieved 10,000 meters in 1988. Among the 10 major economic and technological targets published by the General Company of Unified Distribution Coal Mines in China, our bureau was rated first in six of the categories.

Science and technology is a continually developing process. Technological advance cannot stay at one level and must move forward to keep up with the tide of technological revolution in the world. Our bureau began a second renewal this year, aimed at advanced world standards. In 10 years or more, we wish to build Luan into a vital, efficient, advanced modern coal mine with Chinese characteristics.

Joint Venture Using Japanese CWM Technology

40100029A Beijing CHINA DAILY in English
20 Feb 90 p 2

[Article by staff reporter Xu Yuanchao]

[Text] China and Japan have set up a \$26 million joint venture in East China's Shandong Province, using Japanese technology, to produce coal and water mixture.

The joint venture agreement was signed in Beijing over the weekend between the Yanzhou Coal Mine Administration of Shandong Province, Nissho Iwai Corporation and the JGC Corporation, both from Japan.

The three parties will invest 3.8 billion Japanese yen (\$26.2 million) in the joint venture which will last 20 years. The registered capital will be 1.27 billion yen, about one-third of the total investment.

The remaining 2.53 billion yen will be undertaken by the Japanese firms who will apply to the Japanese Government for bank loans.

The Japanese loans will be paid back in 20 to 25 years according to an official from the China National Coal Import and Export Corporation (CNCIEC).

About 2.36 billion yen out of the Japanese Government loans will come from the Japan International Co-operation Agency at low interest rate.

Of the total investment, the Chinese side will hold 51 per cent, Nissho Iwai 34 per cent and JGC 15 per cent.

Song Jian, State Councillor and Minister in charge of State Science and Technology Commission, said at the signing ceremony that China has known coal deposits of 800 billion tons.

The CNCIEC official said the project will use JGC technology to produce 250,000 tons of coal and water mixture which will all be exported to Japan through Nissho Iwai.

He said the coal and water mixture has been listed by the State Council as one of the priority products that the nation will develop to replace oil in industries over the next few years.

The mixture has the advantages of high combustibility and a low pollution rate. Also, it is easy to transport and store.

An added advantage is that the joint venture will play an important role in expanding China's coal exports to Japan.

The Yanzhou Coal Water Mixture Co. Limited, located in Shijiusuo Port of Rizhao city in Shandong, covers a floor space of 72,000 square metres. The joint venture company will have 60 staff including four managers from Japan.

The official said JGC had selected the fine coal of the Yanzhou coal mine after tests on many types of coal from a number of countries.

The fine coal will be transported by rail to Shijiusuo for processing and pumped through a pipeline to shipping.

Experts Discuss Nation's Nuclear Power Development Issues

906B0032A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 14 Dec 89 p 1

[Article by Liu Litian [0491 7787 1131]]

[Text] The Chinese Nuclear Industry Economic Research Institute held a meeting in Beijing today to discuss the development of nuclear industry in China. Experts participating in the meeting believed that the development policy based on pressurized water reactor (PWR) should not be changed.

Renowned experts Jiang Shengjie [1203 5110 7132], Zang Mingchang [5258 2494 2490], Wang Zhou [3769 3166], Tang Zide [3282 4793 1795], and Zhao Renkai [6392 0088 1956] attended the meeting.

Most experts believe that with 30 years of development history, PWR is a mature technology known for its safety and economy. Seventy percent of nuclear power plants in the world use PWR; this type of reactor will be the mainstay in the near future. China has made good progress in its nuclear power development using PWR.

Based on the experience of designing and building Qinshan Nuclear Power Plant, China will develop a number of 600,000-kW power plants. The emphasis in China's development of nuclear energy will be standardization and serialization.

Experts say that China has its own supply of nuclear fuel, which ensures the next phase of PWR power plant development. To satisfy the large need for nuclear power in the next century, however, China should rely mostly on fast neutron breeder reactors. The rate of utilization of nuclear fuel in a fast neutron breeder reactor is about 70 times higher than that in a PWR. The technology for breeder reactors is maturing and should be China's direction for nuclear energy after PWR.

The experts call for a development that is scientifically based, stable, and long term. The state should establish a policy to systematically accomplish the generation of nuclear power in China by the Chinese as soon as possible. Only then can the development of nuclear power in China be assured.

Huge Growth Predicted for Nuclear Energy

906B0032B Beijing GUANGMING RIBAO in Chinese 2 Jan 90 p 1

[Article by Wang Ganchang [3769 3227 2490], Academic Committee member, Chinese Academy of Sciences, and nuclear physicist]

[Text] The 1990's of the 20th century will be an important 10 years in China's peaceful utilization of nuclear energy.

A 300,000-kW nuclear power plant built by the Chinese themselves will complete the pressure testing of its main circuit and systems in March 1990. Nuclear fuel will be installed in August, the reactor will reach criticality in November, and the power level will be raised in December for power generation.

After the Qinshan nuclear power plant, the No 1 and No 2 reactors of the Dayawan nuclear power plant in Guangdong, both 900,000-kW units, will be installed. They will be fueled in 1992 and 1993 and then connected to the power grids.

In the early 1990's, the two 600,000-kW power plants of the second phase construction at Qinshan, which will be built mainly by the Chinese themselves but with some foreign help, will begin their general design and related research. If everything goes well, they may be completed in mid or late 1990's. In the meantime, a third 300,000-kW plant, China's first nuclear power plant to be built with local funds, will begin optimization design and implementation.

In addition, China also plans to continue purchasing foreign nuclear power equipment to build the Liaoning nuclear power plant. While buying foreign facilities, China will also enter the international market with its own nuclear power plant equipment and technology.

Using sea water as its fuel, controlled thermal nuclear fusion can produce enormous energy. Fusion research will see major advances in the next 10 years. Major breakthroughs in controlled fusion may occur in the early part of the 21st century, putting fusion into practical use.

China began its research on controlled thermal nuclear fusion in the 1960's and made important advances in inertia confinement nuclear fusion using laser beams. Beginning in 1978 China established several inertia confinement fusion research groups and built a high current accelerator. In 1987, an experimental facility was completed for laser induced nuclear fusion. In the meantime, magnetic confinement nuclear fusion research conducted by research institutes in Changdu and Hefei has also achieved encouraging results. Today, controlled nuclear fusion has been listed as a priority item in the long-term planning of China.

In the area of controlled fusion, China will keep up with the state-of-the-art international level and strive to excel in the area of new energy technology in the near future.

China will try to make major progress in reactor technology in the 1990's. For example, state-of-the-art pulsed reactors and low-power reactors will begin operation and enter the international market. Major research results will also come from cold neutron source studies.

Water purification using nuclear power will make significant advances in the 1990's. Hazards caused by pulp waste water will be greatly reduced. Advances will also be made in China on the prospecting and mining of

nuclear fuel. Uranium ore from a medium-sized mine was found to be of high quality; its mining will provide important fuel for China's nuclear technology development.

Long-Range Strategy for Nuclear Power Development

906B0032C Beijing GUANGMING RIBAO in Chinese
14 Dec 89 p 2

[Article by Hu Youquan [5170 2589 3123]]

[Text] The Chinese Institute of Nuclear Industrial Economy held a meeting in Beijing on the development problems in China's nuclear power industry. Fourteen renowned nuclear experts including Jiang Shengjie [1203 5110 7132], Zang Mingchang [5258 2494 2490], Wang Zhou [3769 3166], Tang Zide [3282 4793 1795], and Zhao Renkai [6392 0088 1956] participated in the discussion on how to develop China's nuclear energy industry.

The experts believed that the development of China's nuclear energy industry should be made a national policy. A scientific, stable, long-term development plan is needed to systematically realize the goal of developing China's own nuclear power industry. The state should draft a policy to guarantee the development of nuclear energy in China.

The experts also believed that nuclear power should be the main emphasis in China's development of nuclear energy, and the development of nuclear power should be done in cooperation with foreign countries but mainly with Chinese resources. The development of Qinshan nuclear power plant, designed and built by the Chinese themselves, is progressing well. A similar power plant is planned in cooperation with Pakistan. In the future China should follow a technical approach that combines technology import and self-reliance. Based on the experience of the Qinshan station, a series of 600,000-kW nuclear power plants should be built in order to standardize and serialize China's nuclear power plants.

The experts pointed out that pressurized-water reactors (PWR) account for 70 percent of the world's nuclear reactors and represent a safe, economic, and mature model with a 30-year history; PWR's will continue to be the main reactor in the near future. China should therefore choose the PWR as the main reactor in its development of nuclear power. China should also study fast neutron breeder reactors and other technologically mature models to prepare for the long-term nuclear power development.

Some of the experts pointed out that a highly centralized leadership management system should be established. Other efforts needed are the formation of consulting firms and nuclear power legislation.

**Current Status of Wind Energy Utilization,
Development Strategy**

906B0017A Chongqing XIN NENGYUAN [NEW
ENERGY SOURCES] in Chinese No 10,
5 Oct 89 pp 1-6

[Article by He Dexin [6320 1795 7451], a summary based on many discussions on development strategy for wind energy utilization since November 1979 and on modification and supplemental information provided in June and November 1988: "Current Status and Development Strategy of Wind Energy Utilization in China"]

[Text] Abstract:

The status of wind energy utilization, including wind-powered water pump, wind power generation, wind-assisted navigation, wind heating, wind energy technology and new wind energy conversion devices, is discussed. The potential and effect of wind energy is explained. The development direction of wind energy utilization is predicted and a wind energy utilization development strategy for China is introduced.

Current Status

Since the founding of the new China, wind energy development can be separated into three stages: 1) In the 1950's, effort to develop wind power generators from several dozen to 20 kW began while we were developing conventional windmills. Although no product was developed, we gathered some experience and learned some lessons. 2) In the 1960's, development was focused on modern wind-powered water pumps. More than 600 units of the Model FWG-6 high-speed wind-powered water pump and Model FDG-6 low-speed wind-powered water pump were manufactured and used in the field. 3) Since 1970, wind energy utilization entered a new era. Progress has been made in many areas.

1. Wind-Powered Water Pump

An effective way to alleviate power shortage in rural areas is to develop wind-powered water pumps. Along China's southeast coast, along the coast of Liaoning and Shandong peninsula, and on the islands along the coast, wind energy and surface water are abundant. These are primary areas for pumping surface water with wind energy. In Inner Mongolia, Qinghai, Gansu and northern valley in Xinjiang, wind energy and ground water are abundant. These are primary areas for utilizing wind energy to pump water up from the ground.

The development and application of wind-powered water pump became a mature technology in 1970. Two types of wind-powered water pumps have been developed, i.e., the low lift (less than 5 m) high flow (greater than 20 tons/hour) type for pumping surface water in the south and the high lift (greater than 10 m) low flow (less than 3.5 tons/hour) type for pumping ground water in

the north. Experimental studies showed that wind-powered water pumps developed so far have been rationally designed, can operate stably and reliably, and their performance meets our needs in irrigation, salt making from seawater, breeding in salt water, beach transformation, drinking water supply, and grass field improvement. In use, it has been demonstrated that pumping water by wind power is economically beneficial. For example, 15 wind-powered water pumps were installed on eight wells at three demonstration sites in Xilinguole League in Inner Mongolia between 1980 and 1983. Three wells were equipped with temperature control devices to prevent freezing to ensure the supply of water throughout the year. The cost is lower than diesel-powered water pumps. The salt making plants along the southeast coast not only can save electricity by using wind-powered water pumps, which can alleviate the chronic power shortage situation and replace some of the costly power produced by diesel generators, but also can increase salt production. It should be promoted in salt-works along the coast where there is no power supply or there is a power shortage. Although using wind-powered water pump in breeding aquatic products is a new idea, preliminary experiments carried out at Zhangqiao and Sheyang saltworks in Hongze County, Jiangsu have demonstrated its economic benefit. A new wind-powered pump can irrigate 70-100 mu of field, which is twice the capacity of a conventional windmill (only 30-50 mu). Its energy saving effect is more significant.

The focal point of research on wind-powered water pump in other countries is placed on improving the speed adjustment behavior of the water pump and on matching the wind turbine with the water pump. Research on matching the wind turbine with a centrifugal pump is in progress. The use of a wind power generator to drive an electric water pump and the use of a wind turbine to directly drive a compressed air water pumping system are still in an experimental stage. Using wind to pump water for energy storage has been put on the agenda. The Model FDG-5 wind-powered water pumping system was developed by the Institute of Agricultural Machinery and Xinghua Tractor Factory. Its overall performance has been improved after we put in a side-weighted speed adjustment system, an accessory for the screw pump, and a set of blades with higher wind energy utilization coefficient. The Huhehaote Institute of Machinery for Animal Husbandry placed a speed limiting mechanism on the Model FD4-LB60 wind-powered water pumping system. It operates safely and can be linked to a serial pull rod pump in order to meet different lift and flow requirements with respect to different wells.

2. Wind Power Generation

Wind resources are abundant along the southeast coast of China, along the coast of Liaoning and Shandong and on all islands offshore. These areas are located near the end of the electric grid. The primary goal should be to develop medium and large-scale wind power generators and tie them directly to the grid or to the diesel generator

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19 March 1990

grid to solve the shortage of power for production and to provide power for everyday use. Remote rural areas, such as Inner Mongolia, Gansu, Qinghai and northern Xinjiang, have an abundance of wind energy resources, but no power grid. The focus is then to develop small wind power generators and to operate them independently to provide power for everyday use.

There are two major types of wind power generators developed so far, i.e., the horizontal axis type and the vertical axis type. Based on power, we can categorize them into four types, i.e., mini (under 1 kW), small (1-10 kW), medium (10-100 kW) and large (over 100 kW). Hundred Watt level mini wind power generator technology has matured. It is in mass production and can be widely promoted. Technical hurdles have been resolved for the small 1 kW and the medium 20 kW wind power generators. They are in pilot production for product evaluation purposes. We are working on technical issues associated with wind power generators above 50 kW and prototypes are under evaluation.

Economic benefits have been realized from promotion of small wind power generators and demonstration of medium wind power generators. 1) Power for everyday use has been made available to farmers and ranchers for lighting, television and radio needs. Approximately 50,000 mini wind power generators had been installed in the Inner Mongolia Autonomous Region by the end of 1987. Power was made available to 18 percent of the farmers and ranchers. Siziwang Banner is a demonstration site for this new energy resource. By the end of 1987, 3,425 wind power generators had been installed (1,129 were installed in 1987). Power was made available to 74.9 percent of the ranchers there. The province of Qinghai had over 3,000 mini wind power generators installed and one-third of them are located in Haixizhou, making it available to 10 percent of the people. The Xinjiang Autonomous Region installed over 1,800 mini wind power generators as well. Wind power generators are used by troops stationed on some islands for cooking, heating and health care with very satisfactory result. To generate power for everyday use, most often we use independently operated small wind power generators and batteries to supply dc power. Sometimes, an inverter is used to supply ac current. 2) For industrial use, medium and large wind power generators are usually linked to public power grids. They may also be switched on and off with diesel generators or be put in parallel or series with the diesel grid. Usually, an ac current is supplied. Some operate independently at microwave relay stations and television transmission stations as primary power sources. The 20 kW wind power generator on the island of Dachen can switch in and out of the local diesel generator network (since 1986). The China Wind Energy Technology Development Center and the British Overseas Development Authority (ODA) jointly placed a 60 kW wind power generator on the island of Kongtong in the city of Yantai in Shangdong which can be switched in and out of a 57.8 kW diesel generator. China and the European Common Community are

working jointly to build a wind power/diesel parallel power generation system on Dachen. The three 55 kW wind power generators imported from Denmark by the county of Rongcheng in Shangdong and the 100 kW wind power generator imported from Denmark and located at the shore of Lake Caiwobao south of Wulumuqi are operating in parallel to the grid and have been operating normally. Wind power plant is still in a demonstration of feasibility stage in China. The Xinjiang Wind Energy Corporation is planning to construct a 4 MW wind power plant based on 40 units of 100 kW wind power generators by taking in foreign investment. It is expected to be in operation in 1989.

Since the beginning of the 1980's, the emphasis abroad has been concentrated on the development of 50-100 kW wind power generators. Wind power generators under 150 kW have essentially been commercialized. Some countries have established a wind generator industry. Since 1987, in order to lower the cost of wind generated power, the United States has concentrated on the development of wind power generators above 200 kW in capacity. As of the end of 1985, Denmark installed approximately 1,400 wind power generators internally and exported about 5,000 units. It is an important part of Denmark's industries. Megawatt wind power generators are still in experimental operation. Below 100 kW, wind power generators usually operate independently. Between 100-1,000 kW, most wind power generators are in parallel with the power grid (either individually or in combination as a wind power plant). Recently, more attention is given to the operating mode in conjunction with a diesel generator (in order to solve the dilemma that wind energy is unstable in time and space while user's demand for power is continuous). Wind power plant has become an important indicator that wind energy is entering a practical stage. Utilization of wind energy is considered to have social, economic and environmental benefits.

3. Wind-Assisted Navigation

The research on modern sailing vessels began in the early 1980's. The focal point is on the development of wind-assisted vessels for use in inland waters; 60, 120 and 200-ton sailing vessels have been developed. The operating result shows that the yearly fuel savings reached more than 10-15 percent. Studies on a rotating sail system, an inverted mast system and special sails have been made.

Modern sail boat development began in the 1970's in other countries. There are commercial sail boats in the 1,000 to 10,000-ton class with an energy saving target of 20-30 percent. The Japanese sail-assisted oil tanker (launched in September 1980) can save 50 percent on fuel. An American coastal freighter can save 24 percent on fuel. Various sail designs, such as wing sails with rotors, turbine sails, multi-foil sails, flap sails, inflated sails and kite sails, have been introduced.

4. Wind Heating

Wind heating involves the direct conversion of mechanical energy from the axis of the wind turbine to heat. The advantages include high conversion efficiency and ease of mechanical matching. It can be used in indoor heating, aquatic product breeding and drying of products. The key is the heat generator. Usually, there are four types, i.e., friction, mixing, extrusion and eddy type. The mixing type heat generator developed by the China Institute of Agricultural Machinery has a conversion efficiency of as high as 93 percent. Shenyang Polytechnical University has begun development of an extrusion type heat generator, a heat exchanger and a heat storage device with some success.

Wind heating research has received considerable attention in Japan, the United States, Denmark and Canada. A 20 kW level wind heat generator is being placed in the field. The efficiency of a system utilizing direct conversion of wind energy to mechanical energy to generate heat is approaching approximately 30 percent. Heat generators being developed abroad are mostly of the mixing of hydraulic type.

5. Wind Energy Technology

Wind Machine Performance Test

Currently, the main techniques are wind tunnel testing and wind field testing. Low velocity wind tunnels 16 m (high) x 12 m (wide), 3 m (high) x 3 m (wide) and 4 m (high) x 3 m (wide) are available for wind machine performance evaluation. Wind field testing can be performed at stations located at Badaling in Beijing, Lishan in Zhejiang, Pingtandao in Fujian, Saihantala in Inner Mongolia, and Daludao in Liaoning. Wind-powered water pump test stations were set up in Rushan County in Shangdong and Xinghua, Jiangsu. As for instruments dedicated to wind machine performance evaluation, in addition to imported instrumentation, we also developed a microcomputer-based test system which is capable of monitoring more than 10 parameters such as the operating condition of the wind machine, wind speed, wind direction, rotating speed, voltage output, and power in order to obtain C_p - λ and P-V curves. Furthermore, it can also detect irregular characteristics such as noise and vibration. The wind-powered water pump testing system can record parameters such as wind speed, wind direction, rotating speed, torque, flow rate and angle of deviation.

Survey of Wind Energy Resources

The average grid density of the "National Wind Energy Resources Distribution Chart" prepared in 1981 is approximately 150 x 150 km². In 1987 a detailed survey on wind energy resources was done in 19 provinces and cities along the coast and in the north. The grid density is 80 x 80 km². In provinces along the coast, it is as close as 50 x 50 km². Several key provinces and cities also conducted detailed surveys on their own wind energy resources. Problems such as wind characteristics near

ground level, wind frequency distribution and selection of sites for wind machines have also been investigated.

Basic Wind Machine Theory

The study of basic wind machine theory is addressed in China. It is included in the national technical outline and is an item supported by the State Natural Science Foundation. It primarily contains: 1) Dynamic analysis of the wind machine. The content of the present effort is limited to structural dynamics and its associated problems. This consists of the study of methods to calculate the load distribution in the design of a wind machine, analysis of intrinsic vibration of the structure of a wind machine, study of non-steady-state aerodynamic force and aeroelastic stability of a single blade, aeroelastic analysis of the wind turbine by taking the flexibility of the tower into consideration, load response and fatigue life estimation of wind machine, and experimental studies on wind machine dynamics. The wind energy commission held two technical meetings on wind machine dynamics and plans to hold the third such meeting in the fall of 1989. 2) Aerodynamic design of the wind machine. Design optimization of wind machine is based on the momentum-blade element and the vortex-blade element theory to raise the wind energy utilization factor of the turbine to above 0.40. However, the following problems, such as the aerodynamic characteristics of the foil under low Reynolds' number, large angle of attack and vibration, aerodynamic characteristics of the blade in three-dimensional flow, aerodynamic characteristics of the wind turbine in non-uniform flow (turbulence, gust, wind shear), wind machine wake characteristics, and mechanisms of wind machine pneumatic speed regulating (limiting) devices, still require further investigation. A great deal of basic theoretical work on wind machines has been done by research institutions and universities in China.

Standards for Wind Machine

The National Wind Machine Standardization Technical Committee was established in May 1985. To date, it has formulated the following national standards: model and basic parameters of wind power generators, terminology associated with wind machines, regulation on model number for wind-powered mechanical products, standard for installation of low speed wind machines, and spectrum of wind-powered machine series. The following are under preparation: technical condition for small wind power generator systems, experimental method for small wind power generator systems, technical conditions for wind wheels and blades used in wind power generators, and design standard for small wind power machines.

Accessories to Wind Machines

- 1) Generators: Initially, synchronous generators were used in medium-size wind power generators developed in China. Presently, all generators are asynchronous and

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are made domestically. A 20 kW magnetic field modulated three-phase variable speed constant frequency wind power generator has been developed. It can be placed in parallel to the power grid or to a diesel generator of similar capacity. The study on a dual feedback, variable speed, constant frequency wind power generation system using an inductive generator has been initiated. As for small wind power generators, permanent magnetic generators are mainly used at the hundred Watt level and brushless self-excited generators are mainly used at the 1,000-Watt level. Permanent magnetic generators are in production. Moreover, technical efforts are under way to improve efficiency and reduce starting resistance moment. The brushless self-excited generator has jaw type poles. At 1-5 kW, an optimal speed ratio device may be used to match with the wind machine for best output characteristics.

2) Pumps: Both reciprocating and rotary pumps are used in wind-powered water pumping. The former is primarily used in low lift and high flow situations and the latter in high lift and low flow situations. Rotary pump can be further divided into chain pump, screw pump and centrifugal pump. The chain pump family was invented in China and is widely used in the field. Screw pump has been around for a long time in Europe. It was found to be mechanically superior in use in China for a variety of applications when lift is less than 3 m. Centrifugal pump not only can be used in conjunction with high speed wind machine but also low speed wind machine, not only for low lift but also for high lift. Its matching characteristics ought to be very good. There are a variety of reciprocating pumps available in China to be selected for use.

3) Energy storage: We just started in this area, primarily in energy storage batteries for mini and small wind power generators. Lead acid batteries are used in most cases and their life expectancy is less than 3 years. The technical specifications for batteries used for storage of energy generated by a wind power generator include little maintenance, completely sealed structure, long life (5-10 years), large depth of discharge, strong environmental adaptability, high specific energy by weight (Watt hour/kg) and by volume (Watt hour/liter). It has already been included as a key technical item in the Seventh 5-Year Plan. Work on a silica gel battery has begun. The feasibility of pumping water to store energy has been investigated. Energy storage schemes based on hydrogen and metal phase transition have also been discussed.

4) Inverter: Inverters under 1 kW have been commercialized. High power inverters are under development.

6. Novel Wind Energy Conversion Devices

A feasibility study was done on a cyclone type wind energy conversion device. A diffusion cyclone tower water pumping model design was introduced. Power generating systems based on both wind and solar energy have been investigated and feasibility reports were completed. A prototype power supply consisting of a wind power generator and solar cells was constructed. The "wind tunnel windmill" concept was introduced and a diffusion-injection type of wind energy conversion

device was developed. In conclusion, these ideas are still in a research and development stage and the approach is based on improving the amount of wind energy to be collected.

In the development of wind energy technology, research and development must be done ahead of time, intermediate testing must be strengthened, technical problems must be resolved in a collaborative manner, and advanced technology can be imported. Specifically, 1) in aerodynamics, efforts are concentrated on developing computational methods to improve the aerodynamic characteristics of the wind wheel, studying the effect of aerodynamic force and three-dimensional flow on the turbine (especially a seesaw type wheel) with yawing, developing special airfoil designs for use as wind turbine blade, and investigating the problem of stalling. 2) In structural dynamics, studies are focused on conducting dynamic analysis of wind machine in natural turbulence condition, determining the response of wind machine to load, and estimating fatigue life. 3) In the area of power (rotation speed) control, efforts are concentrated on studying aerodynamic control measures (including blade stalling control, variable moment wing tip, and installation of wind breakers). 4) In site selection of wind field, efforts are focused on studying numerical methods to calculate wind velocity distribution (including effect of terrain on wind velocity distribution and effect of wind machine wake on wind velocity distribution). 5) In the area of energy storage technology, efforts are concentrated on studying energy storage systems (such as wind/diesel system, wind/water system, wind/hydrogen production system, and wind/heat system). Battery technology is essentially solved. It is already used in large wind power generation systems for load adjustment. 6) In the area of matching accessories, efforts are focused on the development of variable speed, constant frequency generators for use in large wind power generator system and centrifugal pumps in wind-powered water pumping.

The development trend of wind energy utilization in the world can be projected as follows: 1) Wind power generation and wind-powered water pumping will remain to be the focal points. Developed nations will concentrate on developing 200 kW level wind machines and they will become primary units for wind power generation plants. Developing nations will focus on machines under 100 kW. 2) Wind power generation plant will be the primary mode of application. 3) Wind energy will be complemented by other type of energy resource to compensate for its intermittent nature. 4) The manufacturing cost for wind machine will be reduced to below \$1,000/kW and its reliability will be raised to over 30 years. The number of maintenance per year will be decreased to once a year and the cost to generate power will be under \$6/kW hour. 5) More accessories will be made available and after sale service will be improved. 6) More novel wind energy conversion systems will emerge.

Development Strategy

As mentioned above, China has made a great deal of progress in the development and utilization of wind energy. However, compared to world class level, there is still a considerable gap. We should seriously plan our work in the Eighth 5-Year Plan based on what we have accomplished in the Sixth and Seventh 5-Year Plans and on special circumstances in China. The following are some preliminary opinions.

1. Continue Development of Small Wind Machine

It has been proven in past practice that a development policy centered around small wind machines to provide electricity for everyday use suits the situation in China. Therefore, we should stay with this policy.

As we continue to develop small wind machines, the following issues need to be addressed:

(1) Performance Specifications. Reliability and safety should have top priority. Data from Inner Mongolia showed that wind turbine is the component with the highest breakdown rate, i.e., 52 percent. The next is the controller, 24 percent. Among various structural components in the wind wheel, blade fracture is the most serious problem, approximately 69 percent. The average life of a wind machine in China is 10-15 years. It is 15-25 years in other countries. In China, the safe wind speed is 40-50 m/sec and it is over 54 m/sec in other countries. There is an obvious gap. A small wind machine should have a wide operating wind speed range, especially a low wind speed (4 m/sec) start-up capability. It is appropriate to pick a rated wind speed at 6-8 m/sec for a small wind machine in China. Projecting the needs of farmers (and ranchers) in the future, it is necessary to develop mini wind machines above 200 Watts.

(2) Product Quality. There is an obvious gap in appearance and quality between domestically made small wind machines and comparable products made abroad. This seriously affects its performance and useful life. The solution is to work on management, perfect industry standard, implement rules and regulations for process control, construct tools and fixtures and strengthen intermediate testing in order to build production bases for small wind machines based on existing foundation in a step-by-step manner.

(3) Energy Cost. Research abroad showed that in areas where the minimum monthly average wind speed is 4.5 m/sec and daily power consumption is under 2.5 kW hour and energy storage battery capacity can only provide power for 36 hours of "windless" situation, a small wind power generator is more cost effective than a small solar power generator or a small diesel generator. Small wind machines should be used in areas where the average yearly wind speed is above 3.5 m/sec and the minimum average monthly wind speed is above 2.5 m/sec. The cost for wind generated power should be controlled to stay within 800-1,000 yuan/100 W.

(4) Wide Range Promotion. "Independent purchase, management and use" will gradually take place. In addition, we have to study and improve the operating system, technical training, and maintenance and repair to make it just as a piece of household appliance.

2. Accelerate Development of Medium Wind Power Generator

The eight medium wind power generation systems developed in China are mostly still in prototype stage and are not available as commercial products. The main problem is poor reliability, including blade fracture, large fluctuation in frequency and power, and severe vibration. Other problems are high cost, poor technology and heavy weight. There is a market for a system with a medium-size wind power generator and a diesel generator running in parallel. Furthermore, it is the foundation for a wind power plant. Problems to be addressed are: 1) To simultaneously focus our effort on the commercialization of 20 kW level wind machine and development of 50 kW wind machine in order to lay a solid foundation for the development of 100 and 200 kW wind machines. 2) The emphasis should be placed on combining wind machine with diesel generator operating as a wind power plant, especially in concert with a diesel generator system of comparable quality. 3) The issue of reliability must be addressed through theoretical calculation, component testing and complete unit testing. The cost should be controlled to stay within 4,500-5,000 yuan/kW.

3. Construct Small Demonstration Wind Power Plants

The objective in the first phase is to build small wind power plants at the 1-5 MW level. Demonstration sites can be constructed in suitable areas in Xinjiang, Shandong, Zhejiang and Guangdong. Wind machines can be first imported and then digested and absorbed.

4. Expand Scope of Applications

More attention should be paid to wind-powered water pumping. The development of medium lift water pumping systems consisting of wind machines and centrifugal pumps will be accelerated. The use of wind-powered water pump in aquatic product breeding and salt making should be promoted. Test and demonstration sites for wind driven water pumps should be perfected. Wind heating should be addressed. The near-term objective is to develop a heater and to match it with the wind machine. Wind-assisted navigation is worth our attention. In the near term, hundred ton level sail-assisted boats should be constructed and used on inland rivers. In the meantime, efforts will be organized to develop thousand ton class sail-assisted boats for navigation along the coast. The use of wind energy in hydrogen production, refrigeration, seawater desalination should also be addressed.

5. Organize Further Survey on Wind Energy Resources

Wind energy distribution patterns up to 50 meters in height should be plotted in major windy regions in the near future. Research on the effects of turbulence and terrain will be initiated. More detailed wind energy resource distribution charts should be plotted for key development areas.

6. Pay Attention to Research on Wind Energy Technology

This should include the following: 1) study of wind turbine blade foil characteristics, including experimental and theoretical studies on the aerodynamic characteristics of large relative thickness and torsion foils at low Reynolds number and large attack angle; 2) study of three-dimensional flow characteristics of wind turbine blade; 3) study of yawing characteristics of wind turbine blade; 4) wind machine dynamics, i.e., dynamic problems associated with a wind machine system in the presence of non-uniform flow (i.e., taking turbulence and terrain effects into consideration); 5) study of wind machine safety protection technology, in addition to continuing perfecting the speed limiting and adjustment devices on small wind machines, the focus should be placed on blade stall control technology and variable tip moment control technology for medium-size wind machines, as well as on sensor, detector and feedback control technology; 6) software packages for designing wind machines; 7) study of the operation of a medium-size wind power generator, with focal points on control technology in parallel to a diesel generator of comparable capacity, voltage and frequency stabilizing technology, load control technology, optimal capacity ratio and fuel savings under specific wind condition and load, technology related to independent and alternate operation and operating range; 8) wind machine performance testing technology, with current efforts concentrated on improving dynamic wind field testing technology, emphasizing bench testing of components, and developing dedicated instrumentation; 9) wind turbine blade processing technology; 10) development of dedicated generators and pumps into a series of products for selection, development of asynchronous motors for medium-size wind power generators, development of centrifugal wind-driven water pumps, and development of inverters for small wind power generators; 11) energy storage technology, with emphasis on the development

of batteries for mini wind power generators, including discharge protection devices, as well as speeding up research on new energy storage systems involving water pumping, hydrogen production and a combination of wind power generation, diesel and battery; 12) power grid connection technology; 13) standardization by accelerating the drafting wind machine standards that suit China's situation and close to foreign standards; 14) study of environmental impact on wind machines, including the impact of wind machine on the environment such as noise and electrical interference and impact of the environment (such as salty fog, ice and snow, sand, dirt, etc.) on wind machine performance; 15) study of novel wind energy conversion systems; 16) study of new energy technology that complements wind energy.

7. Improve the Leadership System and Formulate Directions and Policies

We suggest the formation of a new energy coordination group by relevant authorities to provide overall leadership and draw up plans for the State Science Commission to implement. Under the coordination of the government, the China Wind Energy Development Center, wind energy committees under the China Aerodynamics Society and the China Solar Energy Society, and the manufacturers of wind machines in China can divide up the work rationally and provide mutual cooperation and support. We have to draw up a policy to encourage the use of wind energy, such as providing a subsidy, reducing or waiving tariff, promoting the sale of wind generated power and encouraging investment in wind energy development.

8. Strengthen Technical Exchange and Personnel Training

We should continue importing advanced technology. However, we must avoid blind-folded and duplicated import of technology. Focus should be placed on feasibility studies prior to its import and timely digestion and absorption after its import.

Measures must be taken to accelerate personnel training, including establishing a special organization dedicated to the research and design of wind energy utilization, setting up a special field in new energy resources at higher learning institutions, sponsoring short courses, training graduate students, and sending students to study abroad. The existing profession team must be stabilized.

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